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# THE GRINDING OF SPRUCE FOR MECHANICAL PULP.

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# ILLUSTRATIONS.

PLATES.



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# THE GRINDING OF SPRUCE FOR MECHANICAL PULP.

## COMMERCIAL GRINDING PRACTICE.

The commercial manufacture of ground-wood pulp is generally not conducted according to any fixed standards of practice. Each superintendent or manager has his own theories about the method of grinding. As a result, scarcely any two mills operate under the same conditions, even when grinding the same species and turning out similar products. This is strikingly shown in Table 2, which gives the operating conditions of a large number of mills throughout the United States. For example, one mill producing news paper has 15 grinders, to each of which is applied 135 horsepower; the pressure computed to the basis of a 14-inch cylinder is 17.5 pounds per square inch, and the peripheral speed of the stone is 2,660 feet per minute. In another mill, also producing news paper, each of the 16 grinders has 625 horsepower applied to it and uses a pressure of 72 pounds on a 14-inch cylinder and a peripheral speed of 3,540 feet. A variation of from 135 to 625 horsepower to the grinders is seen in the example cited. While these two mills also show much variation in other conditions of grinding, they do not show the extreme conditions, where the pressure applied to the wood in grinding varies, as shown in the table, from 17.5 to 115.8 pounds on a 14-inch cylinder, and the peripheral speed of the stone from 1,360 to 4,310 feet per minute. The variation in pressure per square inch of pocket area would be more significant, but the data on which to base this computation were not available in all cases.

The reports of power consumption show a range of from 31 to 125 horsepower per ton in 24 hours. Very few mills, however, are able to determine accurately the amount of power consumed in the production of a ton of pulp, for the grinders are nearly always either geared or direct-connected to water wheels or turbines. When turbines are new it is possible to calculate approximately the amount of power produced, but as they become old their efficiency decreases, and it is impossible to calculate the power with any degree of accuracy. It is very probable that many of the reported values are erroneous, especially some of the lower ones, since it has been demonstrated that pulp can not be produced under conditions of present commercial

practice with a power consumption as low as some of the values reported.

In view of the extreme variation in the conditions of manufacturing mechanical pulp it is probable that some of the mills are operating under conditions of low efficiency. While the tests discussed show that approximately the same degree of efficiency may be reached by different combinations of the several variable factors, consistent combinations of these factors do not prevail in the industry.

## PURPOSE OF EXPERIMENTS.

The cost of producing mechanical pulp from spruce must necessarily increase with the cost of the wood. In order to cut down the price of mechanical pulp, therefore, it is necessary either to substitute a cheaper wood for spruce or to increase the efficiency of converting spruce into pulp. Experiments are being conducted in the use of woods other than spruce by the mechanical process, but before these can be carried to a definite conclusion it is necessary that the influence of many variable conditions of manufacture be determined. This can best be done by tests of a standard wood like spruce. Coniferous woods are enough alike to warrant grinding them under approximately similar conditions, and the results of the grinding tests on spruce should be applicable to the production of mechanical pulp from other conifers. The study of spruce, however, is of value not only in establishing relations and standards by which to compare the results of tests of proposed substitutes, but also in developing methods of increasing the efficiency of grinding spruce itself.

The general influence of the variable factors of grinding on the quality and production of pulp has been described in a previous publication [1] of the Forest Service, in which the need for a more thorough study of the conditions of grinding was indicated. The most important factors which enter into the production of mechanical pulp from any species of wood are:

(1) Surface of stone; whether rough or smooth, sharp or dull, or of coarse or fine grit.

(2) Pressure with which the wood is forced upon the revolving pulpstone.

(3) Peripheral speed of the stone.

(4) Temperature of grinding and thickness of stock in the grinder pit.

(5) Physical condition of the wood.

As a result of operating under different combinations of these factors, certain other factors are developed, and it was the purpose of

[1] "Experiments with Jack Pine and Hemlock for Mechanical Pulp," by J. H. Thickens.

the experiments to determine the influence of variation of these upon:

(1) Power applied to the grinder.
(2) Amount of pulp produced in 24 hours.
(3) Power consumption per ton of pulp in 24 hours.
(4) Yield of pulp and screenings per cord of wood ground.
(5) Quality of the pulp.

## EXPERIMENTAL APPARATUS.[1]

### EQUIPMENT FOR WOOD PREPARATION.

For treating woods prior to grinding a steaming or treating tank, holding between one-fourth and one-half cord of wood, is available. This tank is so designed that the wood can be loaded from the top and discharged from the bottom. To carry out tests under different conditions the tank is provided with steam, water, and vacuum connections. A 40-inch swing cut-off saw and a Roberts and Lieberts Green Bay barker are available. A view of the wood room is shown in Plate II, figure 1.

### PULP-MAKING EQUIPMENT.

For grinding, a Friction Pulley & Machine Works 3-pocket grinder, with cylinders 14 inches in diameter, and taking a stone 54 inches diameter by 27 inches face, is used. The grinder cylinders are supplied with water by two Gould triplex pumps. Suitable relief valves are provided for the regulation of the water pressure, and pressure gauges are attached to each cylinder. A graphic recording thermometer connected with the grinder pit gives the temperature of grinding. A Lombard medium-grit stone was used.

The grinder is driven by a direct-connected, direct-current, variable-speed motor, regulated by adjusting the armature voltage. Electric current, alternating, is obtained at 2,300 volts. This is converted by a motor generator set to direct current, the voltage of which can be fixed at any value between 100 and 750 volts by means of a rheostat in the generator field. The measurement of power and the control and regulation of the motor are accomplished by means of carefully calibrated recording, indicating, and integrating instruments. A graphic record is taken of the power applied to the grinder motor, and an integrating watt-hour meter provided in the same circuit makes possible a check on power consumption.

The pulp-screening system consists of a Ruth's centrifugal screen with a plate perforated with holes 0.065-inch in diameter, and operated at 500 revolutions per minute, and a Harmon 12-plate flat

[1] A more complete description of the equipment of the Forest Service laboratory at Wausau, Wis., is given in an unnumbered publication of the Forest Service, "Experiments with Jack Pine and Hemlock for Mechanical Pulp."

screen, the plates of which are slotted with 0.012-inch slots. The Harmon screen is used only in rescreening the tailings of the centrifugal. In forming the pulp laps, a wet machine of the hydraulic 3-roll type is used.

### PAPER MAKING AND TESTING EQUIPMENT.

The experimental pulps were made into paper and tested at the Madison (Wis.) laboratory. A 15-pound Emerson beating engine, a 2-plate flat screen slotted with 0.012-inch slots, and a 15-inch Pusey-Jones Fourdrinier paper machine were used in the manufacture of the paper. A view of the paper machine is shown in Plate II, figure 2.

The strength tests of the paper were made by means of a Schopper breaking-length tester and a Mullen bursting-strength tester. The color tests were made with an Ives tint-photometer.

## METHOD OF OPERATION.

### PREPARATION AND TREATMENT OF THE WOOD.

The wood for the tests was sawed into 2-foot lengths, and the bark removed. Samples were then taken to determine the percentage of moisture and the bone-dry weight per cubic foot. In tests where preliminary steaming was applied the steam pressure was raised as rapidly as possible to the desired value and maintained for the specified time, after which the sections were removed from the steaming chamber and ground as soon as possible. The experiments in which a preliminary steaming or cooking treatment was used are not comprehensive. Additional results on the effect of such treatment will be given in a future publication.

A quantity of pulpwood equivalent to approximately 750 pounds of bone-dry wood was prepared for each test. This was ground as soon as possible to prevent change in its moisture condition from that recorded.

### PULP MAKING.

The pulpstone was worked with a bush roll or burr until the desired surface was obtained. A record of the surface was taken with carbon and coated papers.

To make them comparable all of the tests were started on a cold stone. It was impossible in each case to grind a large quantity of wood for the purpose of heating the stone, since this would have dulled the latter and so have obscured the effects of varying other factors. Tests Nos. 143, 144, and 145 (Table 3) show that starting the tests with a cold stone has very little effect on the horsepower consumption per ton and the production per day. These three tests were conducted under similar conditions, except that No. 143 was run for a period of one hour, 144 for two hours, and 145 for three

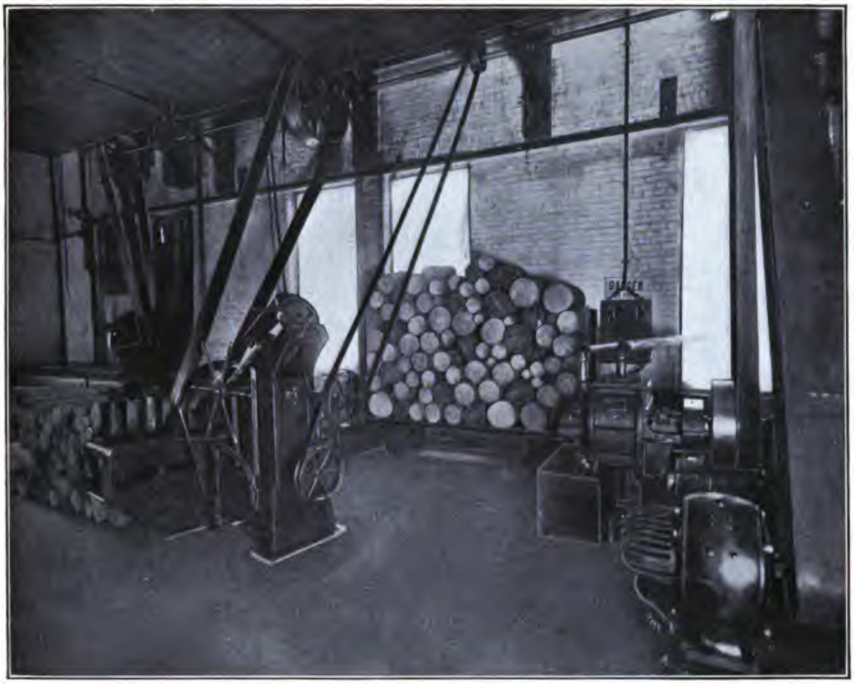


FIG. 1.—WOOD ROOM, GROUND-WOOD LABORATORY, WAUSAU, WIS.

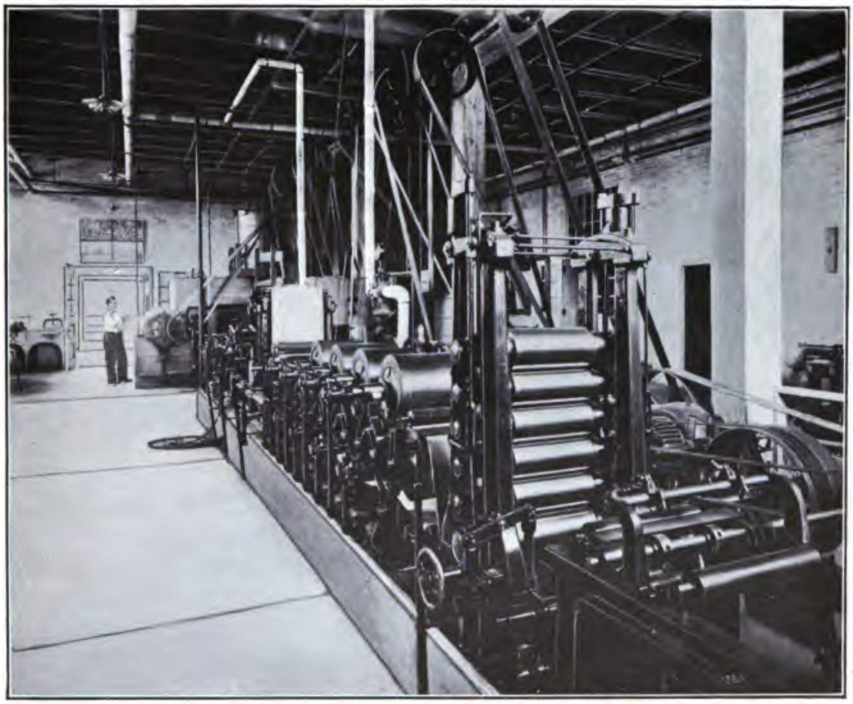

FIG. 2.—PAPER MACHINE, FOREST PRODUCTS LABORATORY, MADISON, WIS.

hours. Tests Nos. 144 and 145 were run on the same day, and the stone had become thoroughly heated before test No. 145 was begun.

In almost all cases the tests were conducted in series, throughout each of which the surface of stone was assumed to remain the same, since any change which might take place would not be great enough

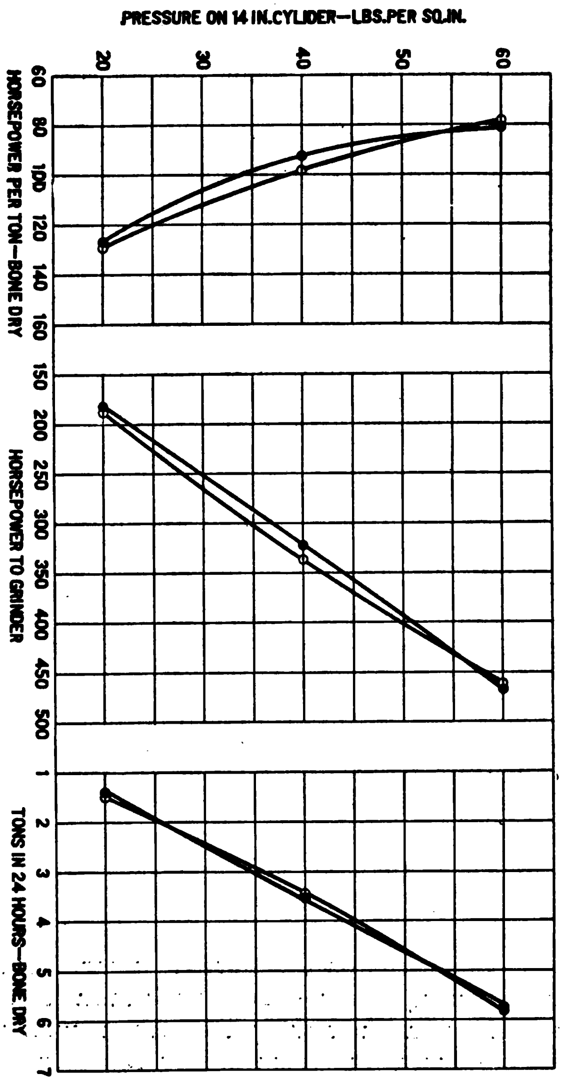


Fig. 1.—Similarity of test values on duplicate runs. (Runs Nos. 137 to 142, inclusive.)

to obscure the influence of the other factors under consideration. Figure 1 (runs 137 to 142) shows that actually the surface changed very slightly during the series of runs. In each case the two tests, which were conducted under the same conditions of speed and pressure, check one another very closely, although the stone had been

used considerably between the tests and the surface had had an opportunity to change. It was found almost impossible to duplicate a surface by successive burrings so that under conditions otherwise similar the power consumption and production would remain the same.

### DETERMINATION OF QUALITY.

To study the quality of the pulp produced two methods were used—microscopical examination and manufacture into paper. The samples for microscopic study were taken from the wet-machine vat. Slides were made and photographed, as a means of comparing the relative amounts of long and short fiber.

In the manufacture of paper from the experimental pulps the laps were shredded and sampled for the determination of moisture, and on a basis of this determination 80 parts by weight (dry) of ground wood pulp were mixed with 20 parts of bleached spruce sulphite pulp. These materials were beaten lightly for approximately one hour, or until all of the fibers had been separated. The beaten pulp was then screened and run into waterleaf paper, the weight of which was maintained as nearly as possible at 32 pounds per ream of 500 sheets 24 by 36 inches. Uncalendered samples of the paper were tested for thickness, weight per ream, bursting strength by Mullen tester, tensile strength and stretch lengthwise and crosswise by Schopper tester. Relative amounts of green, blue, red, and black in the color were determined by means of a tint-photometer. The color determinations were made primarily for comparison with those on pulps produced from woods other than spruce.

In the determination of quality most stress was placed upon strength. However, a grading of the pulps by photomicrographs, according to standards selected from a large number of samples produced commercially, is given (Table 5). Photographs of these standards are shown in the publication, Experiments with Jack Pine and Hemlock for Mechanical Pulp. Since the grading by microscope is not consistent with the results of mechanical tests of strength, not much reliance can be placed upon the examination of the fiber for the determination of quality.

So far as the operation on the machine is concerned—and this is an important item of quality—the tests furnish little information. The paper machine on which the pulps were manufactured operates at extremely low speed, and comments on the freeness of the stock and its general action on the presses, or wire, would have little value.

The comparison of finishes obtained by calendering is also of little value and is omitted. The machine was not run continuously, and the paper was therefore finished at varying temperatures and speeds of the calender rolls.

## RESULTS OF EXPERIMENTS.

### SURFACE OF STONE.

The condition of the surface of the stone depends upon several factors. The size and sharpness of the individual particles of grit, the ease with which the binding material is worn away, and the manner of dressing the stone are important. In these tests but one stone was used, and variations in its surface were obtained by working it with steel rolls of different design.

The size and sharpness of grit should be given considerable attention, although this was not done in the work described. The indications are, however, that stones of fine grit are capable of producing more finely ground pulps, and that a stone of extremely coarse grit may produce very shivy pulp.

Commercially a great deal of attention has been given to the design of burrs or bush rolls. It appears, however, that practically the same quality of pulp can be obtained under like conditions of pressure, speed, and temperature if the surface of the stone is brought to the same condition of sharpness of grit, irrespective of whether the design of the markings is diamond point, straight cut, or spiral. The purpose of the depressions in the stone is primarily to provide a path by which the ground wood can leave it. It is possible that burrs of certain design will give a greater amount of grinding surface than others, and that the production will in this way be slightly increased.

Plates III and IV show some of the bush rolls used in surfacing the stone for runs, the data of which are given in Tables 3 and 4. The surface obtained by burring with the rolls shown on Plate III seemed to give more satisfactory results than any other thus far tried. The stone was first dressed with a 3-to-the-inch roll, and depressions were formed from one thirty-second to one-sixteenth of an inch deep. The stone was then rolled with a 12-to-the-inch spiral-cut burr until the spiral markings were plainly discernible. It is not at all essential that a spiral burr be used; any finely cut burr will give approximately the same results, the idea being, of course, to raise the grit of the stone. This is best done with a burr approaching the grit of the pulp stone in fineness.

The important thing, so far as quality is concerned, is to give the particles of grit the correct treatment, rather than to form a deeply-grooved surface on the stone. An artificial pulp stone so constructed that the binding material, although standing up under high temperature and high pressure, would wear away a little more rapidly than the grit, thus continually exposing new and sharp particles of grit for grinding, would be of immense value to the industry.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 2 shows, by curves obtained at pressures of 20, 40, and 60 pounds, the relation of three different surfaces of stone to the power consumption per ton, power to the grinder, and production in 24

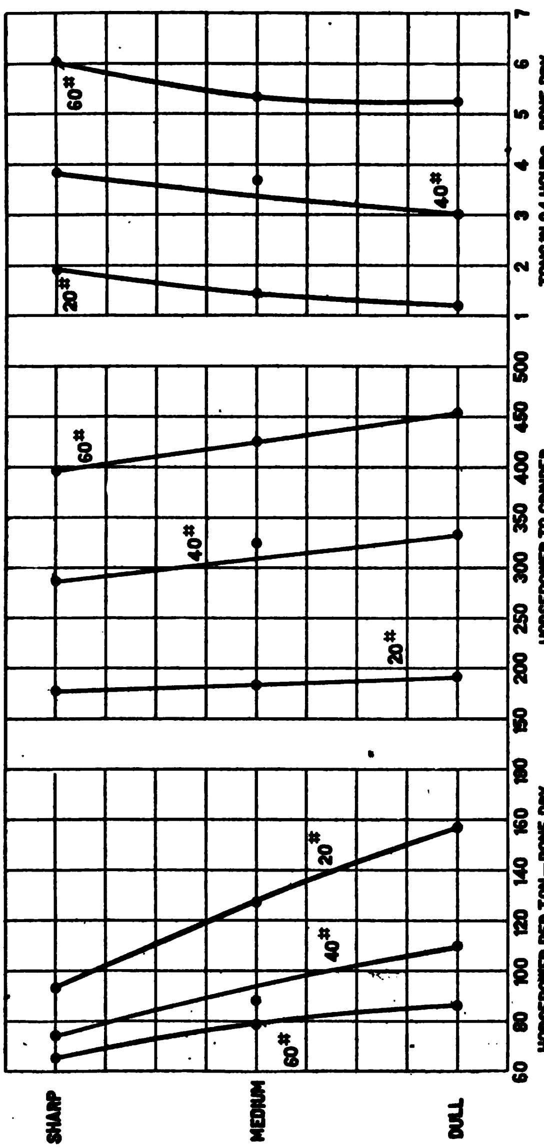


FIG. 2.—Relation of power consumption and rate of production to sharpness of stone, at 175 r. p. m. (Runs Nos. 3 to 5, 9-1 to 11, and 15 to 17, inclusive.)

hours. The horsepower per ton and the power to the grinder va inversely with the degree of sharpness of the pulpstone, while t production varies directly with the sharpness. It is of particu interest to note that the curves apparently come together at a pc

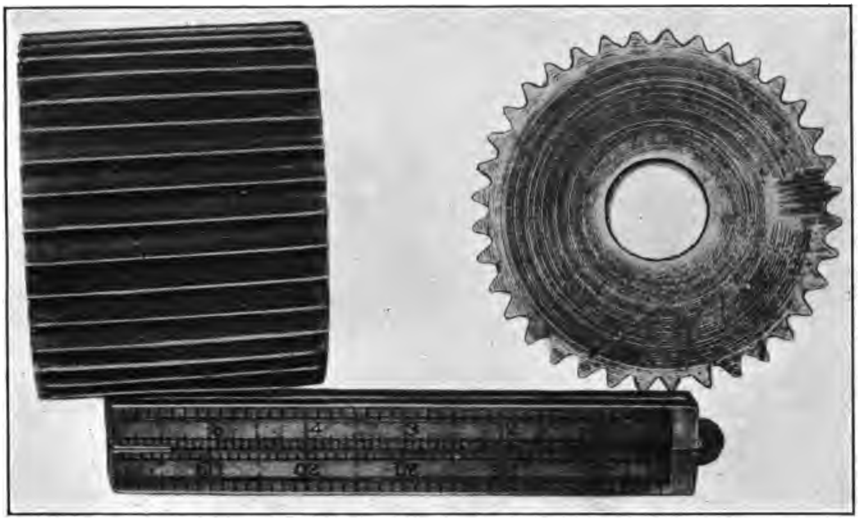

FIG. 1.—STRAIGHT-CUT BURR, THREE TO THE INCH.

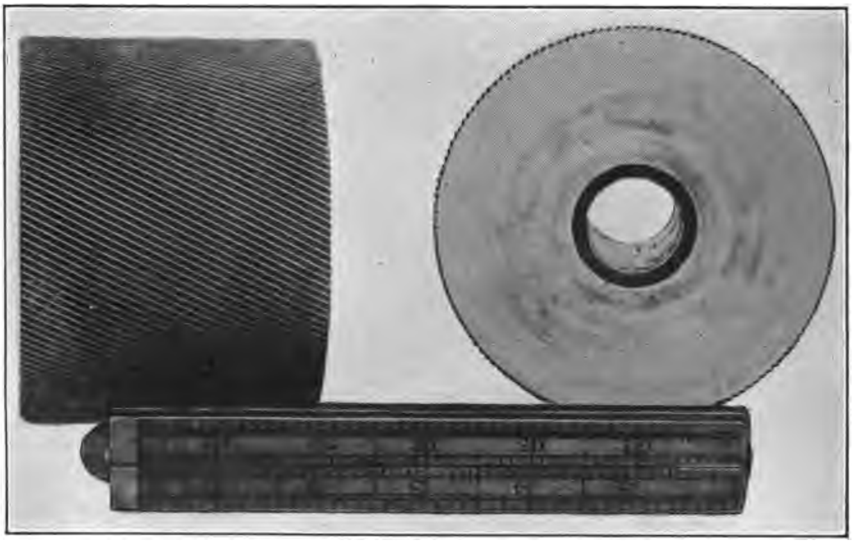

FIG. 2.—SPIRAL-CUT BURR, TWELVE TO THE INCH.

(Advance $1\frac{1}{2}$ inches in crossing 3-inch face.)

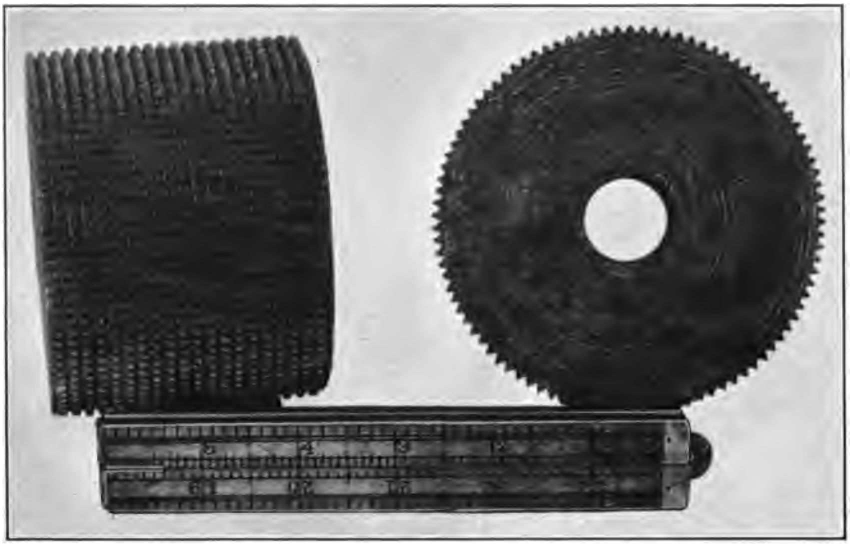

FIG. 1.—DIAMOND-POINT BURR, EIGHT TO THE INCH.

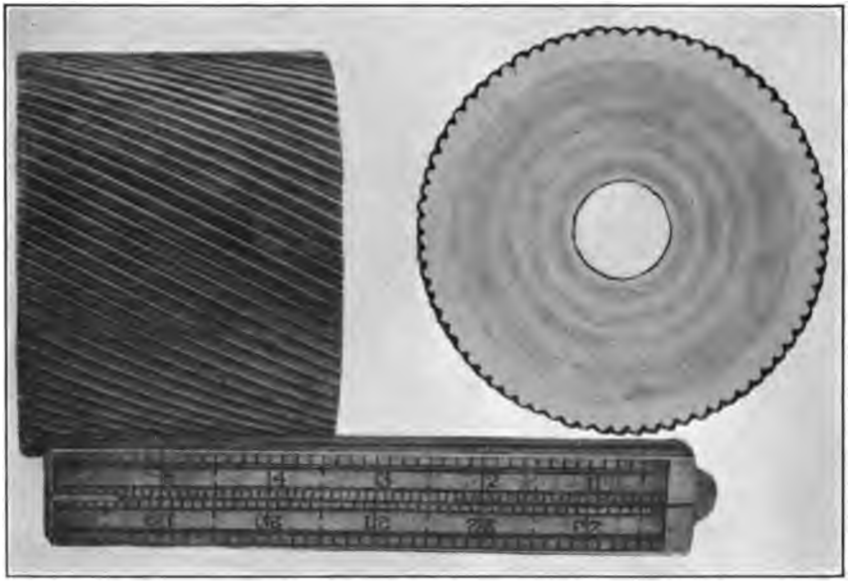

FIG. 2.—SPIRAL-CUT BURR, SIX TO THE INCH.

(Advance 1¼ inches in crossing 3-inch face.)

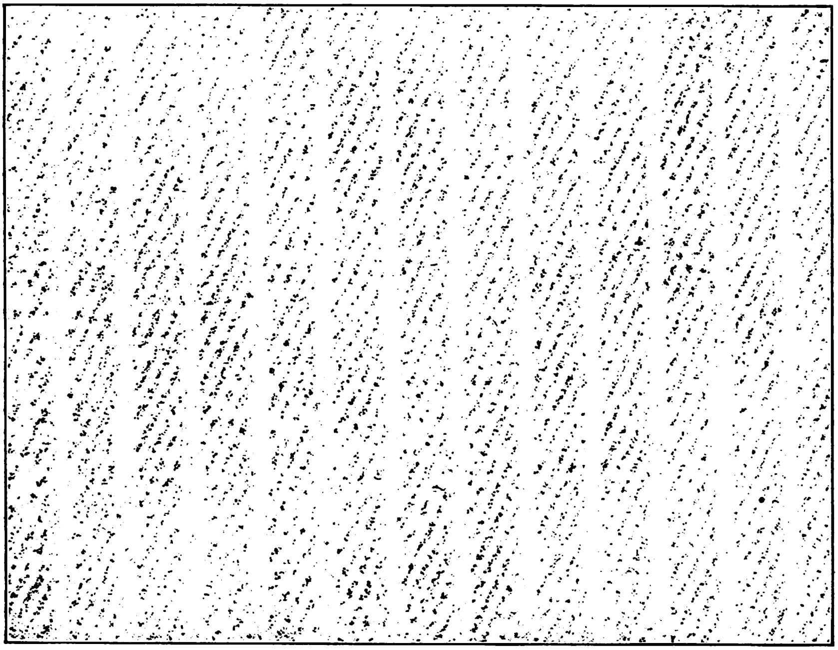

FIG. 1.—SURFACE OF STONE, FRESHLY DRESSED.

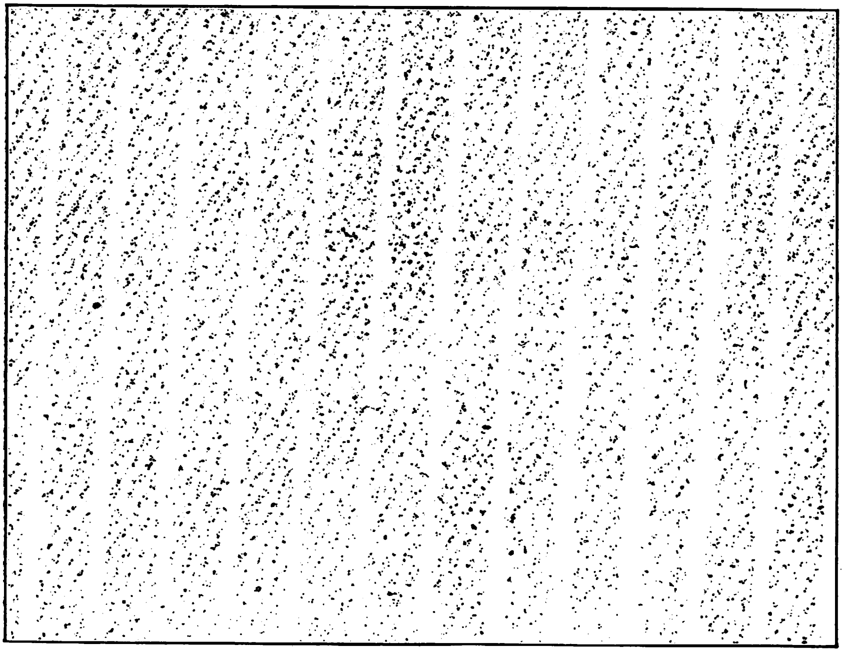

FIG. 2.—SURFACE OF STONE AFTER PRODUCTION OF 12.5 TONS OF PULP.

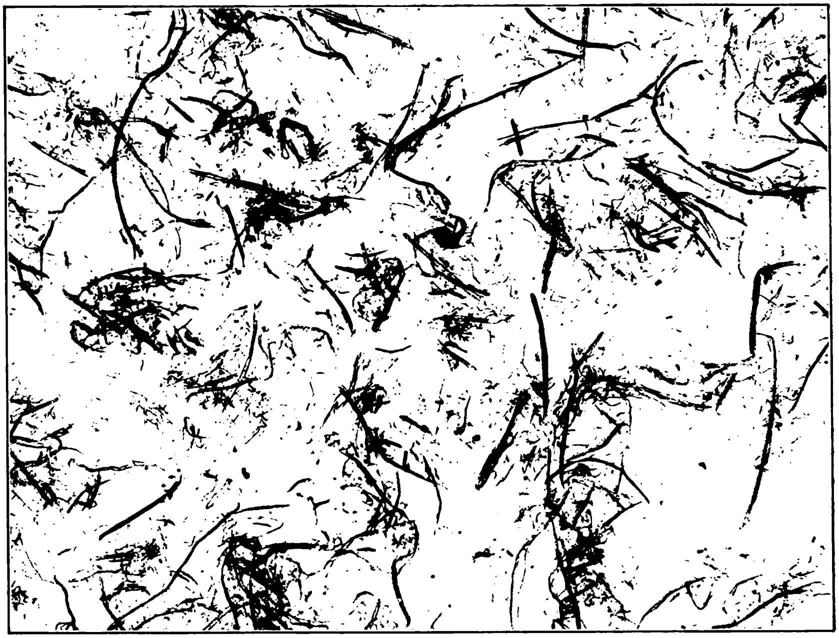

FIG. 1.—SHARP STONE, 64.5 HORSEPOWER PER TON.

FIG. 2.—DULL STONE, 84.5 HORSEPOWER PER TON.

COMPARISON OF SPRUCE PULPS GROUND ON SHARP AND DULL STONES.

(Magnified 15 diameters.)

representing approximately 50 horsepower per ton. This indicates that it is impossible, with the apparatus used, to produce pulp with less than 50 horsepower per ton in 24 hours, no matter what pressure or degree of sharpness is employed. When a low pressure is used, the influence of the condition of the stone on the horsepower consumption per ton is more marked than when higher pressure is applied. This is not the case with the consumption of power on the grinder and the production in 24 hours, which are affected by the surface of the stone to about the same extent at high and low pressures.

Figure 3 is a series of curves similar to those shown in figure 1, except that they were obtained at a speed of 225 revolutions per minute instead of 175 revolutions. The same general characteristics appear in this series as in the other. It is again evident that the curves showing the relation between sharpness of stone and power consumption converge at a point which has a value of approximately 50 horsepower per ton, the sharpness of stone being somewhat greater than the sharpest condition under which the tests were carried on.

Plate V is a reproduction of the surfaces of stone used in a number of tests. Figure 1 of this plate shows the surface before any grinding had been done, and figure 2 shows the same surface after 12.5 tons of pulp had been ground under various conditions of speed and pressure. In figure 1 the spiral markings are very distinct, while in figure 2 they are not as much in evidence, and at the same time the sand particles, represented by the black dots, are fewer in number. This is due to the fact that many of them have been broken or worn off. When grinding at 30 pounds pressure and 225 revolutions per minute, the rate of production for the first two hours after dressing was 3 tons of bone-dry pulp in 24 hours, and the power consumption per ton 112 horsepower. After 12.5 tons of pulp had been made and the stone had become dull the production fell to 1.89 tons in 24 hours, and the power consumption increased to 171.3 horsepower per ton for the same grinding conditions.

### INFLUENCE ON YIELD AND QUALITY.

The condition of the surface of stone apparently has very little effect upon the yield per cord of wood. It is true that with extremely sharp stones more screenings are formed and possibly more fine fiber finds its way into the white water, but within reasonable limits of sharpness the yield shows little variation.

Plate VI shows two photomicrographs of pulp obtained on stones of different degrees of sharpness. In one case a consumption of 84½ horsepower per ton was necessary, while in the other only 64½ horsepower was required. The photographs indicate that a better quality of pulp is produced at the greater power consumption and lower degree of sharpness of the stone. The samples of paper made from

various experimental pulps show, when tested, that paper from pulp produced by the sharper stones has less strength than that from pulp ground on duller ones.

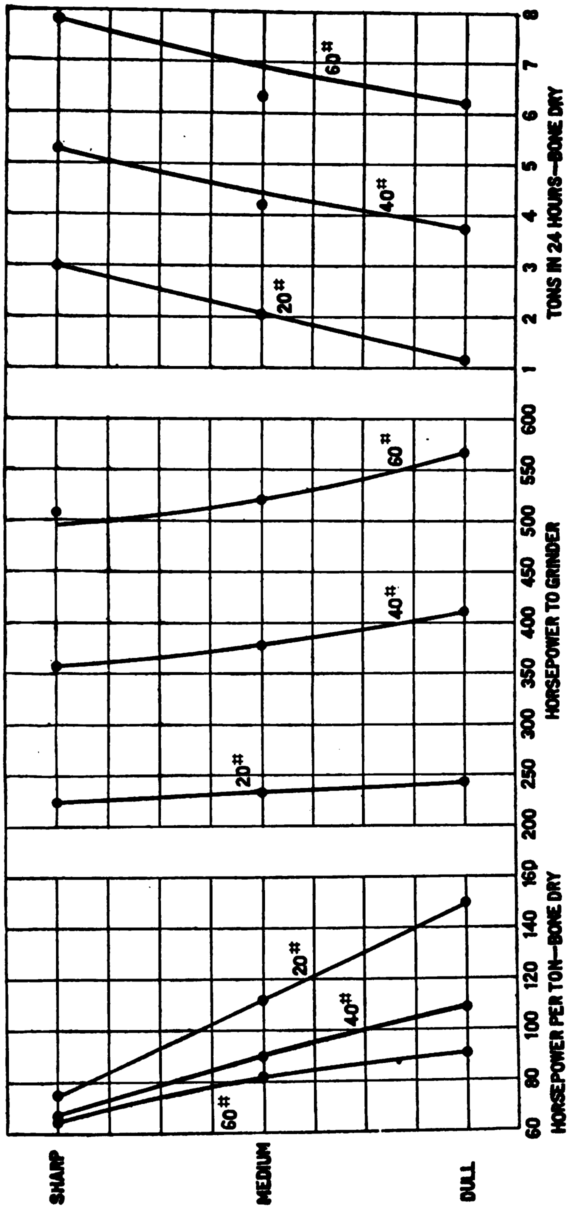


FIG. 3.—Relation of power consumption and rate of production to sharpness of stone, at 225 r. p. m. (Runs Nos. 6 to 8, 12 to 14, and 18 to 20, inclusive.)

In the tests conducted on stones sharpened so that the surface consisted of deep ridges or points and grooves, it was found that the quality of pulp produced was uniformly poor, consisting of very fine

fiber intermixed with coarser particles. When a very sharp surface is used, the wood fibers are literally ground to pieces; a larger percentage of screenings is also made, although not so large as might be expected. Under such conditions the fibers are ground so short and fine that it is almost impossible to remove the lap from the wet-machine press roll.

Deep grooving of the surface of the stone causes more rapid production of pulp, but at the sacrifice of quality. When high power without excessive sharpness of the stone is used, the grit of the stone comes more into play. In fact, the grit of the stone, more than any other factor, influences the quality of pulp produced under conditions of high power consumption.

### PRESSURE ON GRINDER CYLINDERS.

For any given cylinder pressure, the pressure at which the wood is forced upon the revolving grindstone varies greatly with the diameter and length of the material. Besides, the wood may bind in the pockets, and this also results in a variation of the pressure on the stone. In commercial practice the pumps supplying the water to the grinder cylinders often do not have sufficient capacity, and, as a result, the pressure drops off each time one of the pistons is raised or lowered. In order to eliminate this effect some mills have installed triplex or centrifugal-pressure pumps which are directly connected to the grinder shaft. By this means the increased speed of the grinder brought about by raising one or more of the pistons results in increasing the speed of the pump, thus raising the pressure on the other cylinders of the grinder and reducing the speed of the stone to normal. This to some extent brings about a regulation of the speed, but causes a wide variation in the pressure. Because it is claimed that any change in the pressure results in a great change in the quality of the pulp, some manufacturers have provided their grinders with devices which are supposed to bring about uniform conditions of pressure. While it is undoubtedly true that the latter greatly influences quality, it is doubtful whether any appliance or apparatus thus far placed upon the market eliminates to a marked extent the variation of pressure of the wood on the pulpstone.

Though in the experiments discussed in this bulletin the pressure of the wood upon the stone varied, it is reasonable to suppose that the variation due to difference of length and diameter of the wood, binding of the wood in the pockets, and similar causes, has a fairly constant range for any cylinder pressure and consequently does not affect the deductions regarding the relative influence of different cylinder pressures upon production and power consumption.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 4 shows the relation of the pressure on the grinder cylinder to the horsepower per ton, power to the grinder, and production in

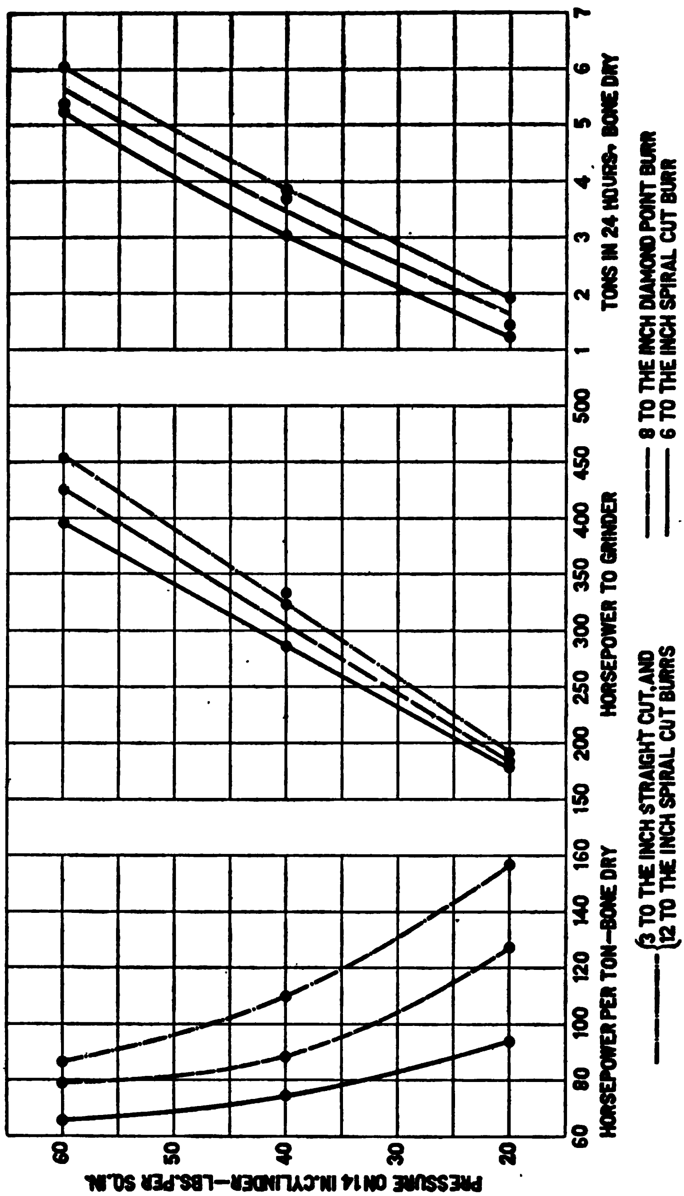


Fig. 4.—Relation of power consumption and rate of production to pressure at 175 r. p. m. (Runs Nos. 3 to 5, 9-1 to 11, and 15 to 17, inclusive.)

24 hours. The three curves represent surfaces of different degrees of sharpness and are plotted from the same data as those shown in figure 2. On the sharpest stone there is a very slight decrease in the

power consumption per ton with increasing pressure, and on the dullest one a marked decrease in power consumption as the pressure

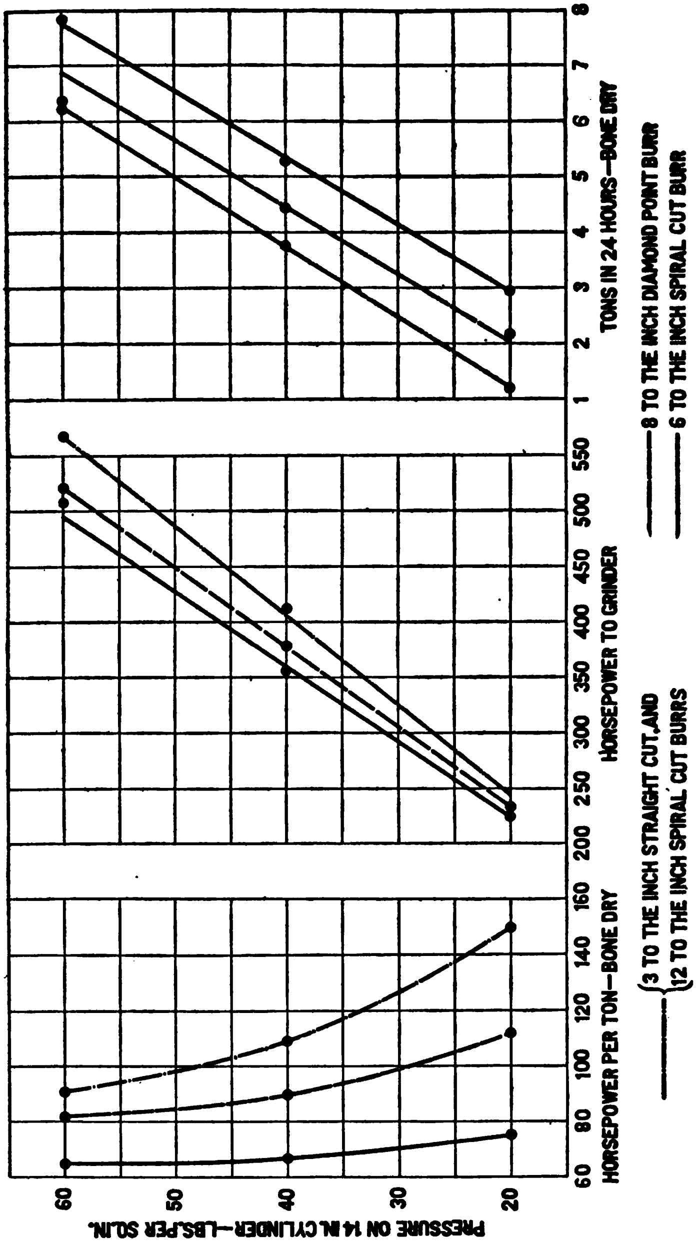


FIG 5.—Relation of power consumption and rate of production to pressure at 225 r. p. m. (Runs Nos. 6 to 8, 12 to 14, and 18 to 20, inclusive.)

is raised. The power to the grinder varies directly with the pressure on the cylinders; the same is true of the production in 24 hours.

The variation of the same factors at a speed of 225 instead of 175 revolutions per minute is shown in figure 5.

The relation between pressure on the grinder cylinder and a quantity, C, derived from the formula $C=\frac{H}{PS}$, where H is the average horsepower to the grinder, P, the pressure in pounds per square inch of pocket area, and S, the peripheral speed in feet per minute, is shown in figure 6. The quantity C is proportional to the coefficient of friction of wood on the stone under the conditions of speed and pressure of the tests. There is a gradual decrease in the value of C, as the pressure of grinding is raised. The values for horsepower per ton also decrease with higher pressures, as shown on the curves between pressure and horsepower consumption. Of the two curves given in this figure, one illustrates the variation of C with pressure when steamed wood was ground, and the other when untreated wood was used. The variation of the quantity C with factors other than pressure and condition of wood may be obtained from Tables 3 and 4.

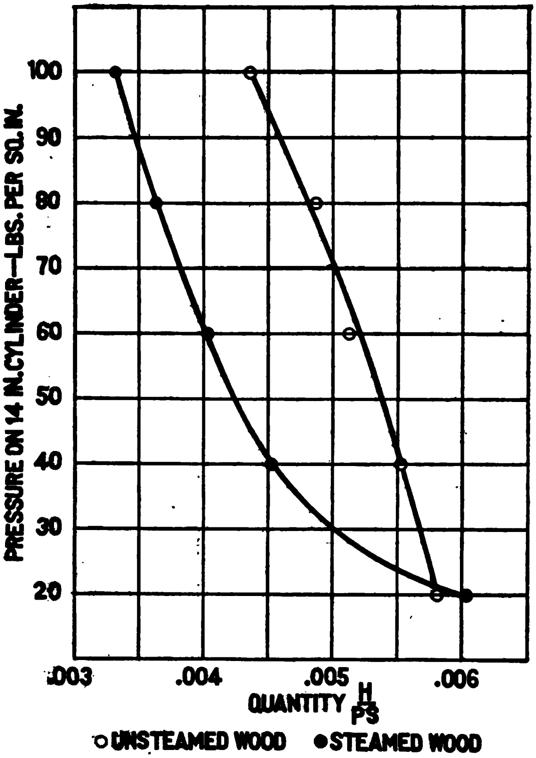


FIG. 6.—Relation of quantity $\frac{H}{PS}$ to pressure. (Runs Nos. 52 to 56 and 97 to 101.)

Figure 7 shows the relation of pressure on the grinder cylinders to power consumption per ton, power to the grinder, and production in 24 hours, when only two pockets on the grinder were used and the pressure was raised very high. The decrease in power consumption with increase in pressure is seen; the minimum value of the power consumption is approximately 55 horsepower per ton. As was shown in figures 4 and 5, the power to the grinder and production in 24 hours vary directly with the pressure on the grinder cylinder. It is interesting to note that under the same conditions of speed and surface of stone the horsepower to the grinder would be approximately 275 and the production 3 tons of bone-dry pulp in 24 hours if 40 pounds pressure were used, while if the pressure

were raised to 100 pounds per square inch the horsepower required by the grinder would be doubled, but the production in 24 hours would be more than trebled.

Figure 8 shows the relation between the number of pockets used and the horsepower consumption per ton of pulp. In this test the power to the grinder and the speed were maintained constant; the power was utilized by varying the grinder pressure according to the number of pockets used. When using one pocket and a pressure of 120 pounds per square inch the consumption per ton was 58 horsepower, while with three pockets and a pressure of 36½ pounds the power consumption per ton was approximately 89 horsepower. This is only another way of demonstrating that the power consumption per ton of pulp in 24 hours is much lower under conditions of high pressure of grinding than under conditions of low pressure. This test is of interest to manufacturers, because it suggests that by using a smaller number of pockets they can procure a larger quantity of pulp during times of low water without sharpening the stone to an unusual degree.

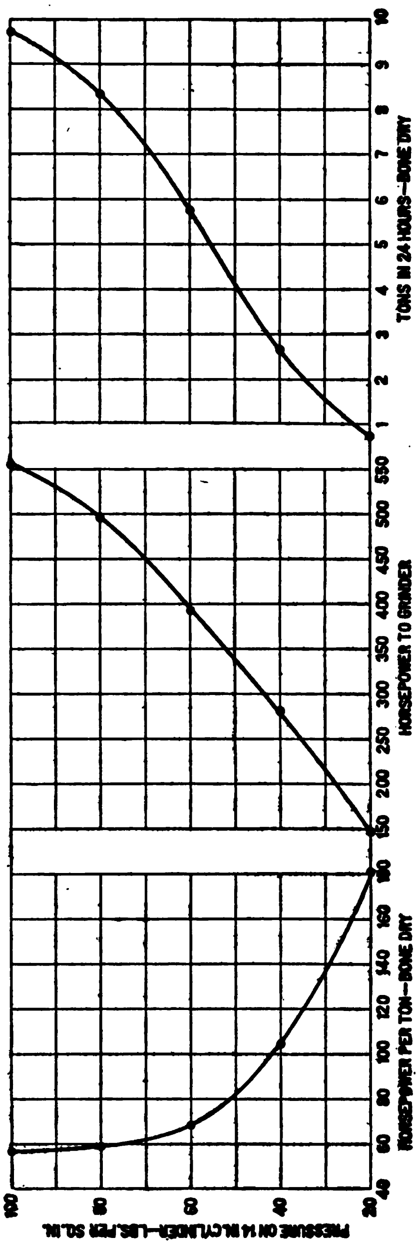


FIG. 7.—Relation of power consumption and rate of production to pressure at 225 r. p. m., 2 pockets. (Runs Nos. 52 to 56, inclusive.)

The relation of pressure on the grinder cylinder to horsepower per ton, horsepower to the grinder, and production in 24 hours when the wood was steamed prior to grinding is shown in figure 9. In this case the pressure has not nearly so marked an effect upon the various factors as it had in the tests shown in figure 7. The wood was

steamed for a period of six hours at 60 pounds pressure, and two pockets were used in the grinding.

INFLUENCE ON YIELD AND QUALITY.

Figure 10, which shows the relation between yield per hundred cubic feet of solid rossed wood and the pressure on the grinder cylinder, indicates that with increasing pressure the yield of pulp increases. Although the amount of screenings also increases, there is a gain in the yield of screened pulp at high pressure, due to the smaller quantity of pulp in the white water. The increase was approximately 11.5 per cent in the tests on which this figure is based.

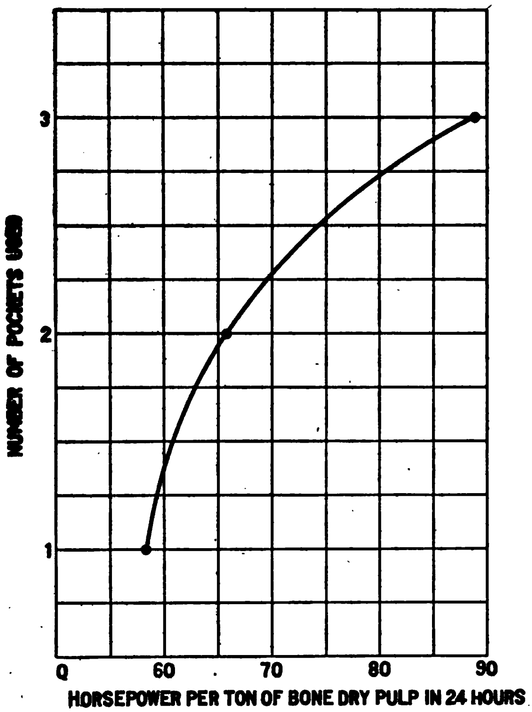


FIG. 8.—Relation of power consumption to number of pockets used at 225 r. p. m., 330 horsepower to grinder. (Runs Nos. 120 to 122, inclusive.)

The effect of pressure on the quality of pulp, as indicated by the strength of the paper, is shown by figure 11. The strength factor, or the bursting strength per square inch divided by the weight per ream, decreases with increasing pressure. The decrease in the strength of the paper with the power consumed in making a ton of pulp is also shown.

PERIPHERAL SPEED OF STONE.

In most commercial plants the peripheral speed of stone is given little attention, and perhaps rightly so. When the pressure on a pocket of the grinder is removed the speed will increase greatly unless controlled by a governor. The effect of this increased speed is generally more beneficial than otherwise, since it prevents, to some extent, a decrease in the production of pulp with the smaller number of pockets in operation. There are conditions of operation which require a fairly constant speed, and the use of a governor is therefore desirable, especially when the peripheral speed is high. It is easy to

see that the removal of the pressure from a pocket, especially if a very high one were being carried, might so relieve the stone that the speed

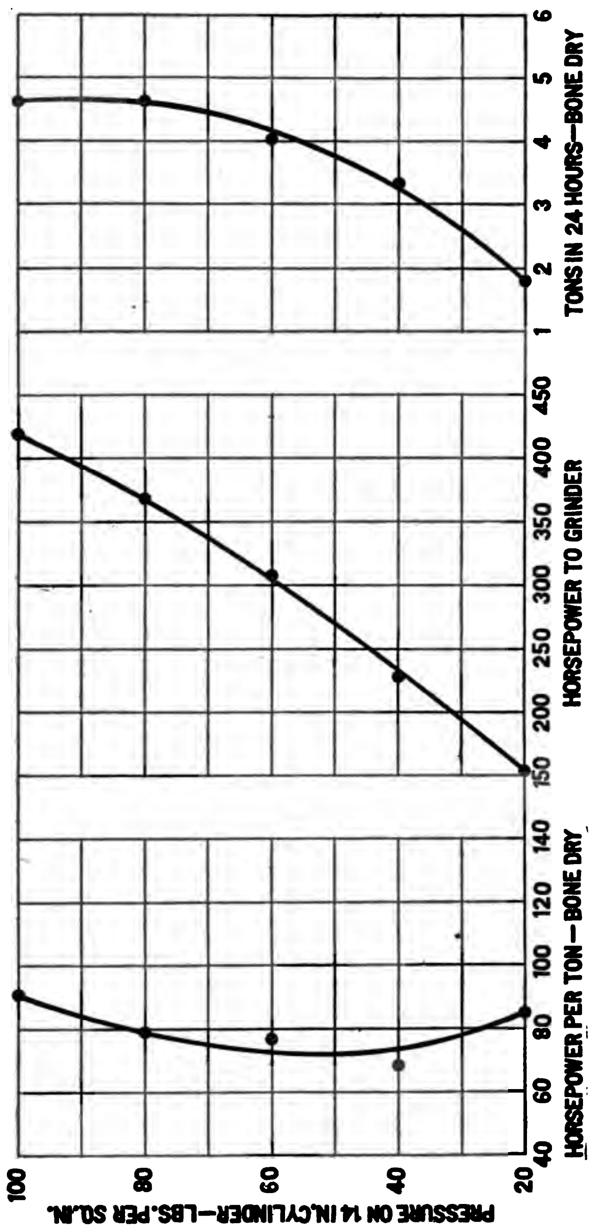


Fig. 9.—Relation of power consumption and rate of production to pressure at 225 r. p. m., 2 pockets, steamed wood. (Runs Nos. 97 to 101, inclusive.)

would increase to a dangerous degree. However, stones are generally operated considerably below their bursting speeds.

INFLUENCE ON THE POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 12 shows that the power to the grinder varies directly with the speed, as does also the production in 24 hours, but to a greater extent. This results in a lower power consumption per ton with

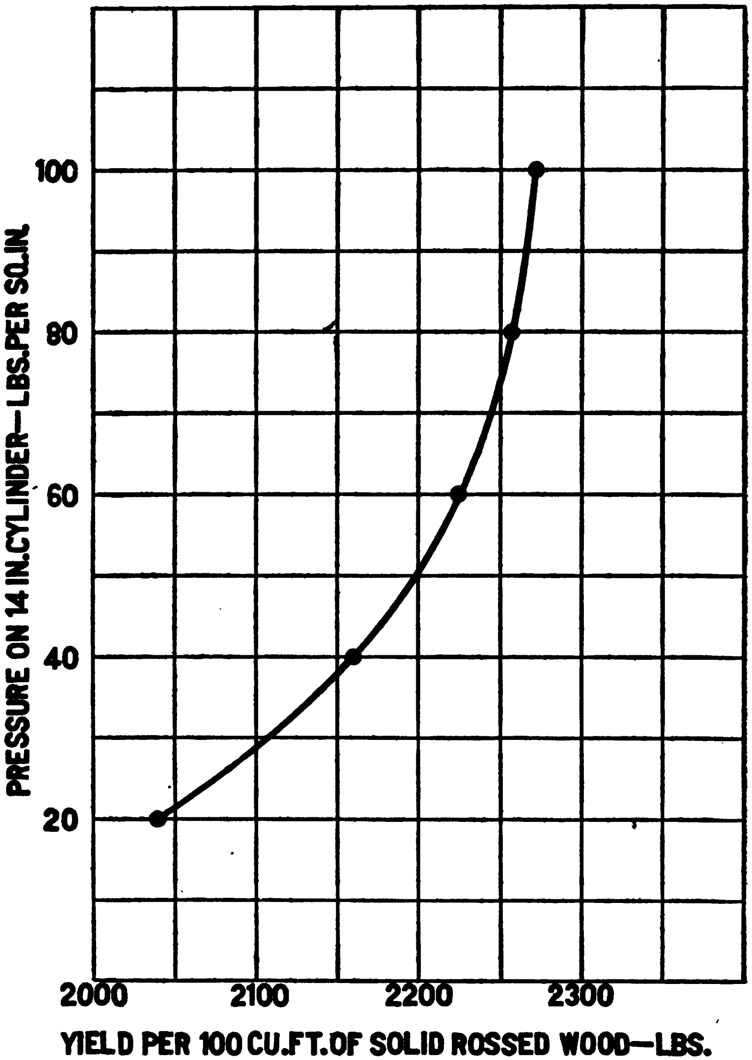


FIG. 10.—Relation of yield to pressure, 225 r. p. m., 2 pockets. (Runs Nos. 52 to 56, inclusive.)

increase of speed. In these tests the pressure was maintained constant.

In the tests plotted in figure 13 the power to the grinder was maintained as nearly constant as possible, and both the pressure and speed were varied, though so adjusted as to utilize the power in each case.

With constant power to the grinder the production in 24 hours is practically constant, regardless of whether the pulp is produced at low pressure and high speed or at high pressure and low speed, although there seems to be a very slight decrease in the production at low speed and high pressure. This effect is seen more clearly in the

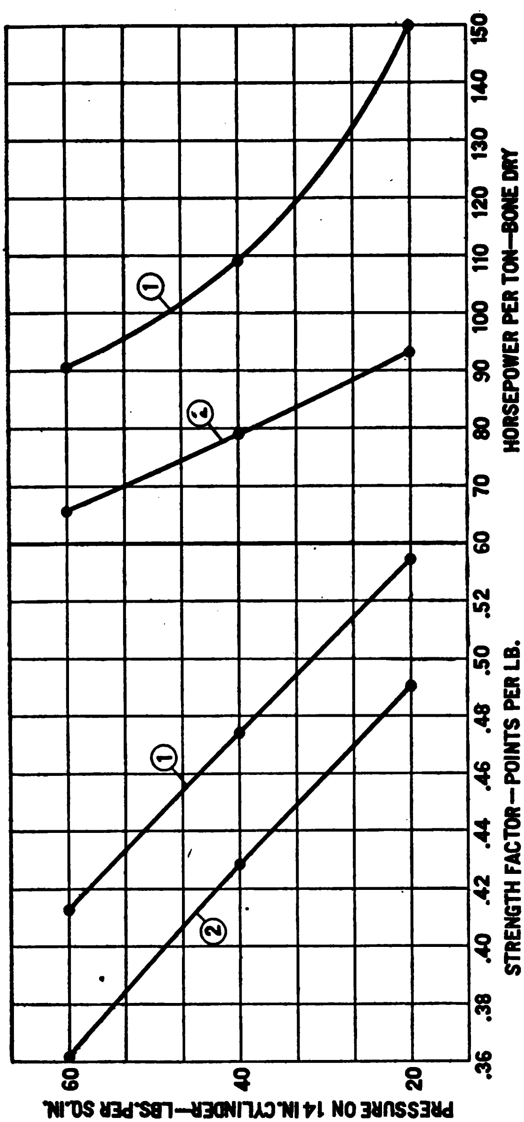


FIG. 11.—Relation of strength of paper and power consumption to pressure at 175 r. p. m. (1) and 225 r. p. m. (2). (Runs Nos. 6 to 8, and 9-1 to 11.)

curve for horsepower per ton. While the power consumption per ton of pulp is practically constant, there is a slight increase as the pressure increases and the speed decreases. In commercial practice the grinders ordinarily receive a certain amount of power direct, and

it was thought that pressure and speed could be so combined as to secure a maximum production of pulp from the power supplied to the

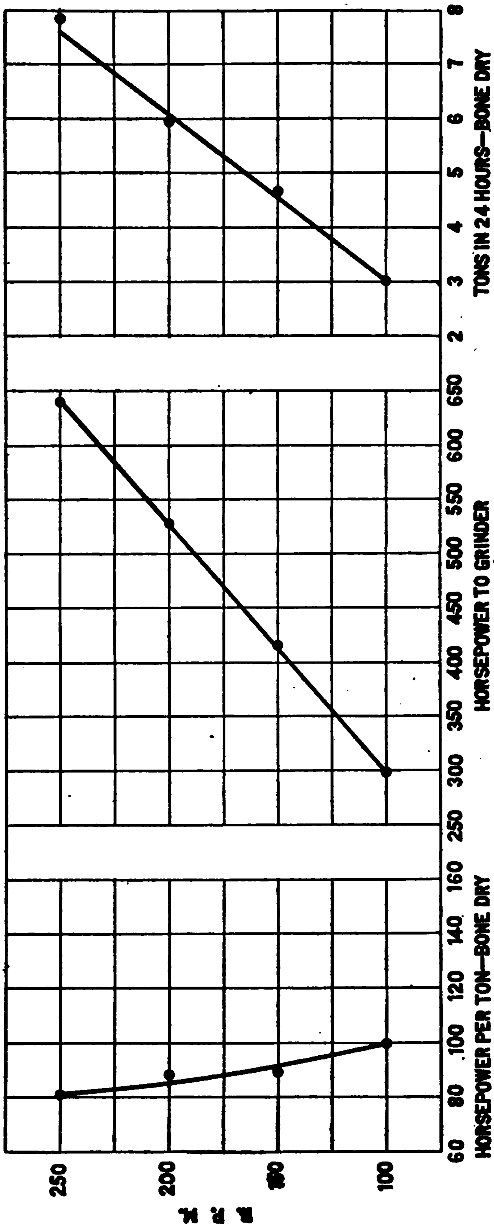


Fig. 12.—Relation of power consumption and rate of production to speed at 60 pounds pressure. (Runs Nos. 24 to 27, inclusive.)

grinder. This, however, did not prove to be the case, since in the range covered in the tests the production was practically constant.

INFLUENCE ON YIELD AND QUALITY.

The yield per cord and quality of pulp are only slightly influenced by the speed. The yield appears to be somewhat higher with high

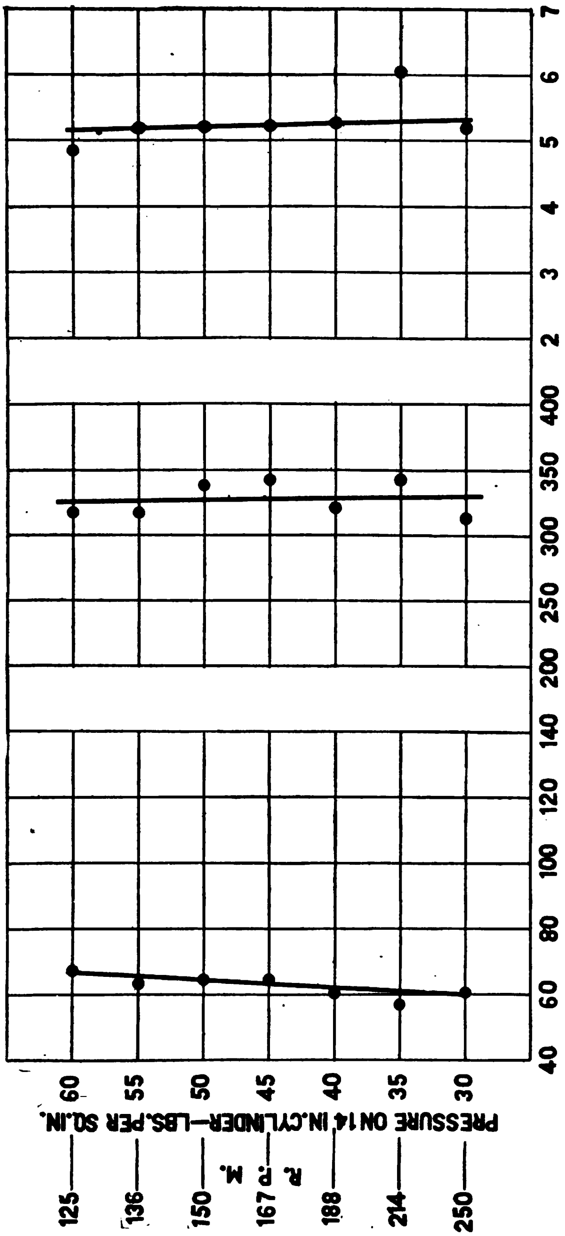


FIG. 13.—Relation of power consumption and rate of production to pressure and speed; 330 horsepower to grinder. (Runs Nos. 32 to 38, inclusive.)

speed; the difference, however, is small. The quality as determined by strength tests of the papers is not influenced so much by speed as

by pressure of grinding. There is, however, an increase of strength with decrease of speed.

The relation of speed and of pressure to strength by Mullen test in points per pound is shown in figure 14. The tests on which this curve is based are the same as those shown in figure 13. The strength of the paper is greater, the power to the grinder being constant, when the pulp is produced at high pressure and low speed than when it is produced at low pressure and high speed.

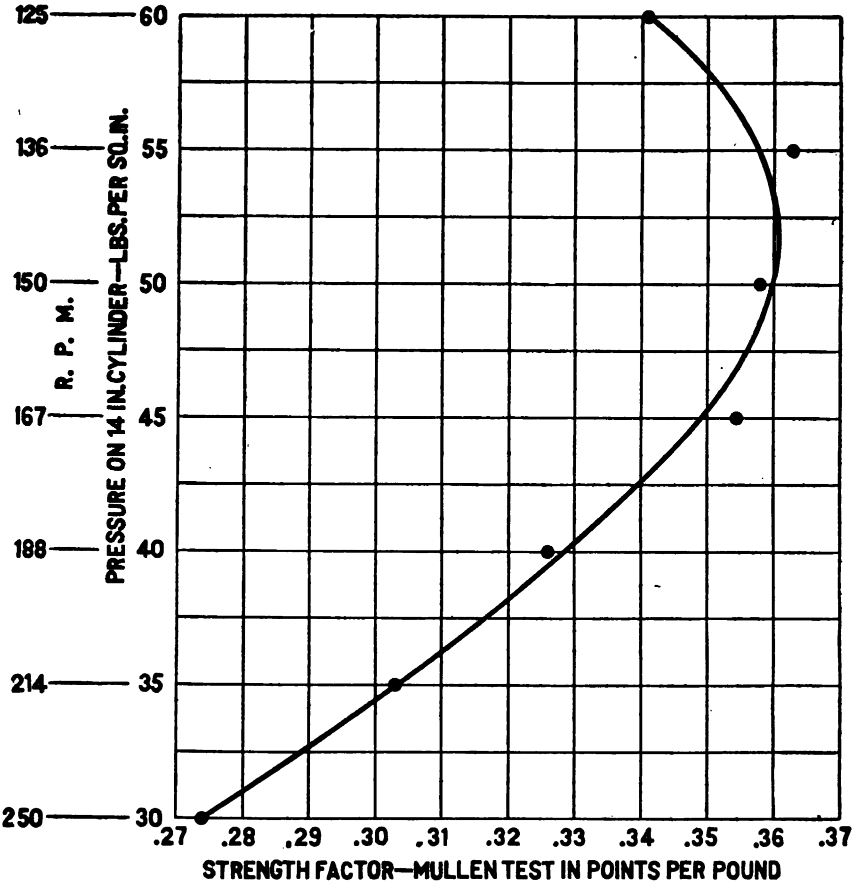


FIG. 14.—Relation of strength factor to speed and pressure; 330 horsepower to grinder. (Runs Nos. 32 to 38, inclusive.)

## TEMPERATURE AND THICKNESS OF STOCK IN THE GRINDER PIT.

The effect of the temperature at which mechanical pulp is produced has long been the cause of a difference of opinion between American and European manufacturers. American paper-making practice requires in almost all cases the production of ground wood at high temperature, and it is claimed that pulp so produced has stronger

and longer fibers and is considerably tougher than cold-ground pulp and works "freer" on the machine. On the other hand, it is claimed that cold-ground pulp is finer, freer from shives, that it gives a better "closed" sheet of paper, and has greater opacity than hot-ground pulp. These points, however, are difficult to prove or disprove. A number of tests were run to determine the effect of cold grinding upon factors of economic production, but most of the experiments were made by the hot-grinding process.

The thickness of pulp in the grinder pit is another factor which is claimed to have an important influence on the paper produced. Many manufacturers run their pulp extremely thick, while others run it comparatively thin. Some claim that a stone will not clean itself unless the stock is very thick, and that, as a result, there will be more or less regrinding of the pulp with thin stock. The tests discussed in this report were conducted, for the most part, with thick stock in the grinder pit.

#### INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Table 3 (tests Nos. 39 to 50, 133 to 136, and 155 to 158) contains data secured under conditions of hot and cold grinding and shows that varying the temperature from cold to hot has little effect upon the power consumption or power to grinder, but the production in 24 hours is somewhat higher under conditions of hot grinding. Table 1 gives the amount of power required to rotate the grinder at various speeds without load, but with stock of different consistency in the grinder pit. To overcome the friction of the pulp and bearings of the grinder when a thick stock was employed, from 12.4 to 18.7 kilowatts were required; with a very thin stock in the grinder pit from 2.7 to 10 kilowatts were needed. A maximum difference of 14.5 kilowatts between the power required for thick and for thin stock in the grinder pit occurred at 175 revolutions per minute. This amount of power, when calculated to the basis of power consumption per ton of pulp, becomes negligible.

TABLE 1.—*Power to the grinder in kilowatts at different speeds, without load, with thick and thin stock in the pit.*

| Condition of stock. | Power to grinder. | | | | | | |
|---|---|---|---|---|---|---|---|
| Revolutions of stone per minute | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| | *Kilowatts.* | *Kilowatts.* | *Kilowatts.* | *Kilowatts.* | *Kilowatts.* | *Kilowatts.* | *Kilowatts.* |
| Thick | 12.4 | 14.9 | 16.3 | 18.7 | 14.0 | 14.0 | 15.3 |
| Thin | 2.7 | 3.4 | 3.1 | 4.2 | 6.0 | 8.0 | 10.0 |
| Difference | 9.9 | 11.5 | 13.2 | 14.5 | 8.0 | 6.0 | 5.3 |

### INFLUENCE ON YIELD AND QUALITY.

The temperature of grinding and thickness of stock in the grinder pit do not influence the yield per cord of wood. The quality of pulp, however, is affected. The pulp produced at high temperature is long fibered, while a fine-fibered pulp is more easily secured by the cold-grinding process.

Table 5 (tests Nos. 39 to 50, 133 to 136, and 155 to 158) gives daat of tests of paper made from pulp manufactured at different temperatures. It appears that the temperature has very little influence on the properties determined by these tests.

### PHYSICAL CONDITION OF THE WOOD.

The question of the influence of the physical condition of the wood is a very important one. Wood for pulp is almost invariably allowed to season for a long period before it is used, and as a result there is considerable loss due to rotting, and the wood becomes darker in color. It is more difficult to secure a long-fibered pulp from wood which has been seasoned for a long period than from green material. The treatment of wood by steaming, boiling, or some similar process prior to grinding is important, because by such treatment better fibers can be obtained than when woods are ground without treatment. This makes possible the use of woods which, if ground in the natural state, would yield very short-fibered pulps. In this way, too, pitchy woods can be made usable by the mechanical process.

In commercial practice it often happens that wood is ponded for a long time before it is ground. Unfortunately, wood of this kind was not available for test.

### INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

It was shown in figure 9 that when the wood had been steamed prior to grinding for six hours at a steam pressure of 60 pounds per square inch, the horsepower consumption per ton varied but slightly with variation in pressure. There is a decided contrast, however, in the forms of the curves of power consumption and rate of production obtained on untreated and steamed wood, as may be seen in figure 15.

The relation of the pressure on the grinder cylinders to the horsepower consumption per ton, horsepower to grinder, and the production in 24 hours, when green, seasoned, and steamed woods were ground is shown in figure 16. At low pressures the power consumption per ton of pulp is higher for seasoned wood than for steamed wood, while at high pressures the reverse is true. For green wood the average power consumption is lower than for either seasoned or steamed material. The power to the grinder for either seasoned or green wood under like conditions of speed and pressure is practically the same,

but it is less for steamed wood. This is due, undoubtedly, to the more slippery condition of the steamed material. The rate of production of

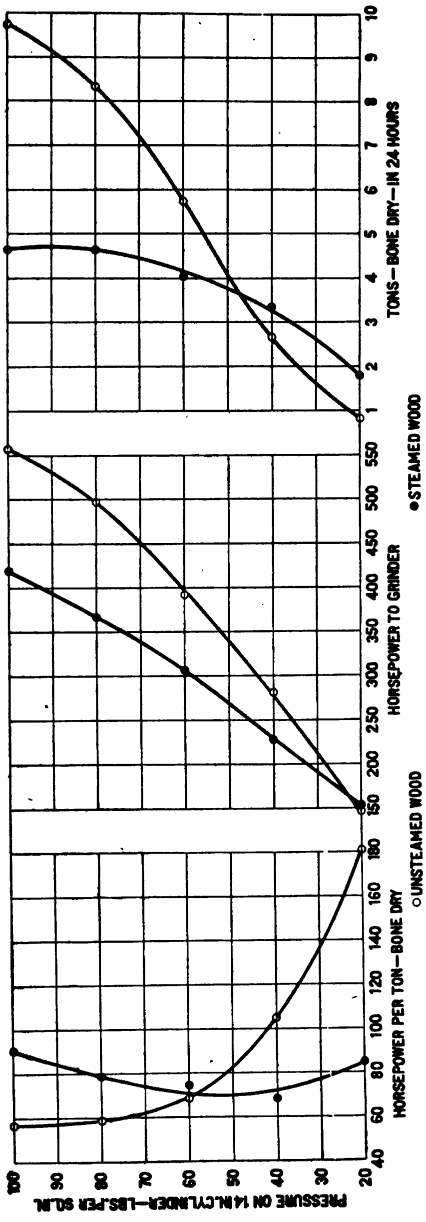


FIG. 15.—Comparison of variation of power consumption and rate of production with pressure at 225 r. p. m., steamed and unsteamed wood. (Runs Nos. 52 to 56 and 97 to 101, inclusive.)

pulp from green wood is more rapid than from either seasoned or steamed wood.

#### INFLUENCE ON YIELD AND QUALITY.

Figure 17 shows graphically the weight per cubic foot of various woods and the yields secured from them under like conditions. The

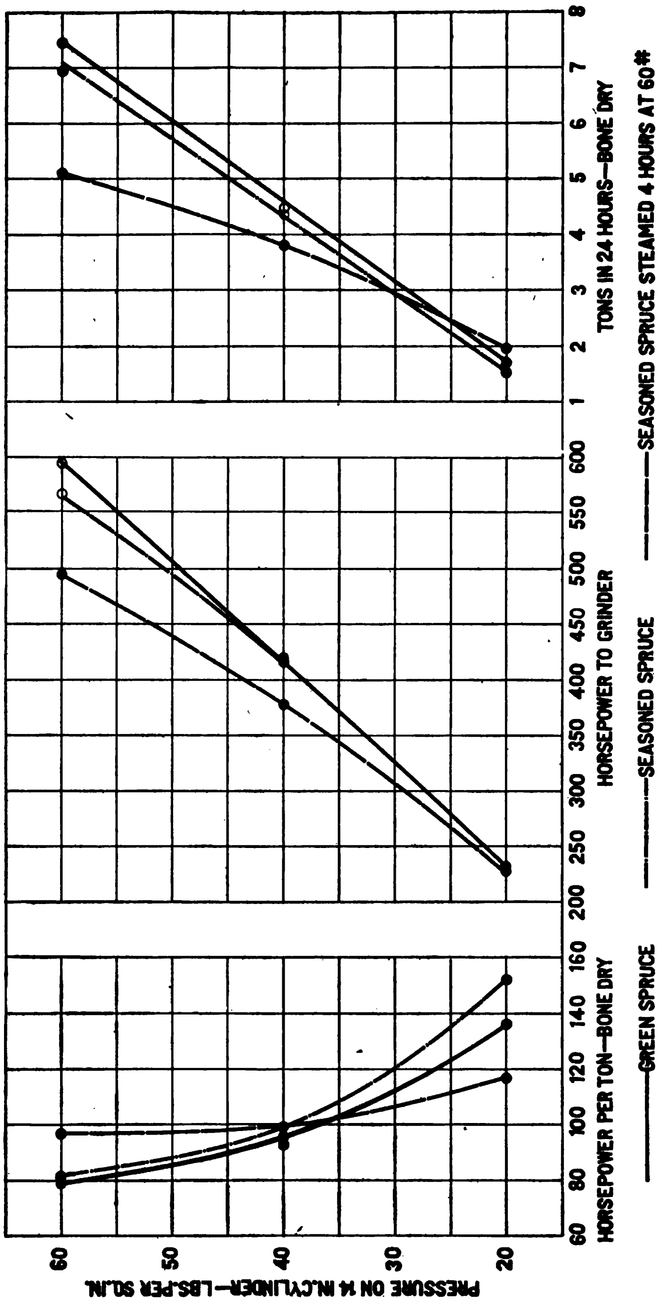


Fig. 16.—Comparison of variation of power consumption and rate of production with pressure at 225 r. p. m., green, seasoned, and steamed wood. (Runs Nos. 124 to 132, inclusive.)

woods tested had been steamed for a period of six hours at a pressure of 60 pounds. The species, with numbers corresponding to those in the figure, were:

1. Western yellow pine (*Pinus ponderosa*).
2. Lodgepole pine, Montana (*Pinus contorta*).
3. Western larch (*Larix occidentalis*).
4. Lodgepole pine, California (*Pinus contorta*).
5. White spruce (*Picea canadensis*), normal growth.
6. Red fir (*Abies magnifica*).
7. Aspen[1] (*Populus tremuloides*).
8. Balsam fir (*Abies balsamea*).
9. Jack pine (*Pinus divaricata*).
10. Hemlock (*Tsuga canadensis*).
11. Tamarack (*Larix laricina*).
12. Paper birch[2] (*Betula papyrifera*).
13. Sitka spruce (*Picea sitchensis*).
14. Western hemlock (*Tsuga heterophylla*).
15. White spruce (*Picea canadensis*), rapid growth.

The yields are almost directly proportional to the bone-dry weight of the wood per cubic foot. In the same figure the relation between yield and dry weight is shown when unsteamed wood was used. In this case also the two factors vary directly.

The yield of pulp per 100 cubic feet of solid wood appears to be approximately the same from seasoned and green wood. It is very probable, however, that on the basis of a cord of rough wood the yield would be smaller for seasoned material on account of the decayed portions. The yield of pulp from steamed wood is a great deal lower than from seasoned or green material. This may be due to the solvent action of hot water on wood, and the assumption is strengthened by the fact that the yield becomes less as the treatment is prolonged or the steaming pressure raised. The relation between yield and duration of treatment is shown in figure 18. It is probable also that the yield from ponded wood is lower than from dry or green wood, on account of the dissolving action of the water.

The quality of the pulp does not seem to be influenced greatly by the moisture content of the wood or weight per cubic foot. However, by treating the wood prior to grinding the strength is much increased and the color darkened. Therefore, when strength is the important factor steaming prior to grinding raises the quality of the pulp, but when light color is one of the chief considerations the quality is greatly lowered.

Plate VII shows two photomicrographs of pulp produced under the same conditions; the one from wood which had been previously steamed, and the other from unsteamed wood. The effect of steaming is readily discernible in the appearance of the fiber.

[1] Generally called "popple" in Wisconsin.

[2] Generally called white birch in Wisconsin.

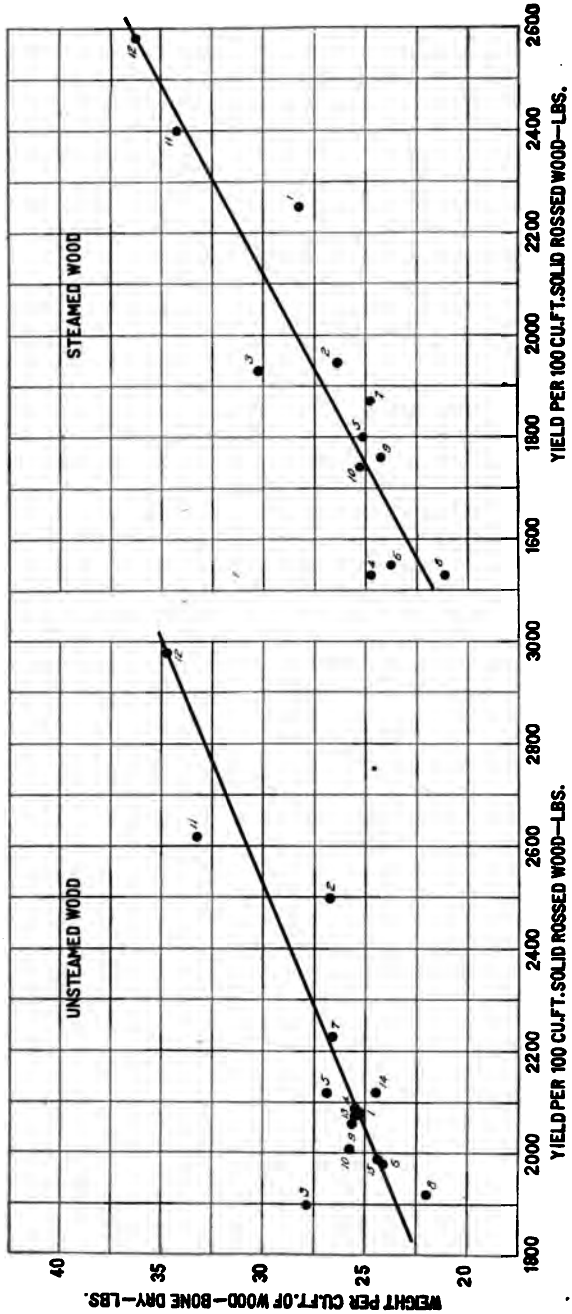


FIG. 17.—Relation of yield to dry weight of wood, steamed and unsteamed.

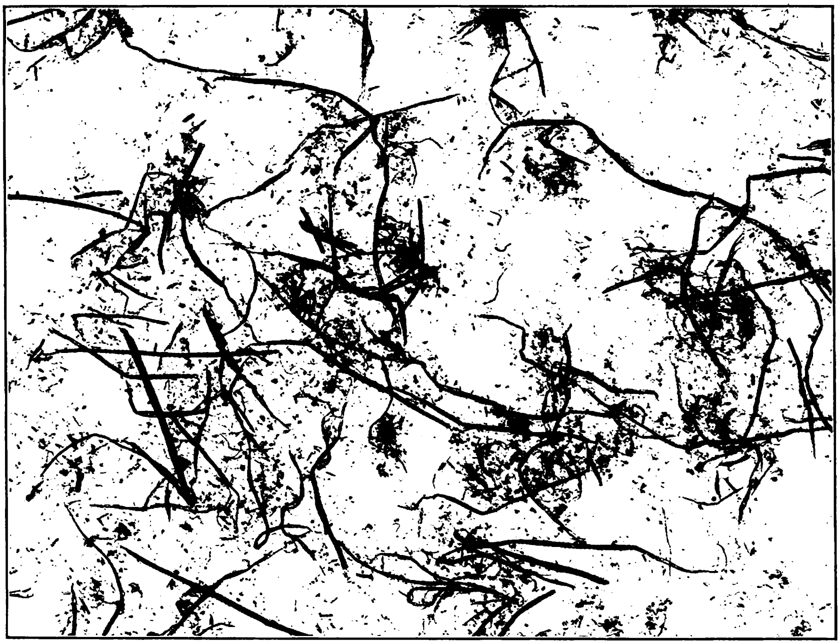

FIG. 1.—STEAMED WOOD, 220 HORSEPOWER PER TON.

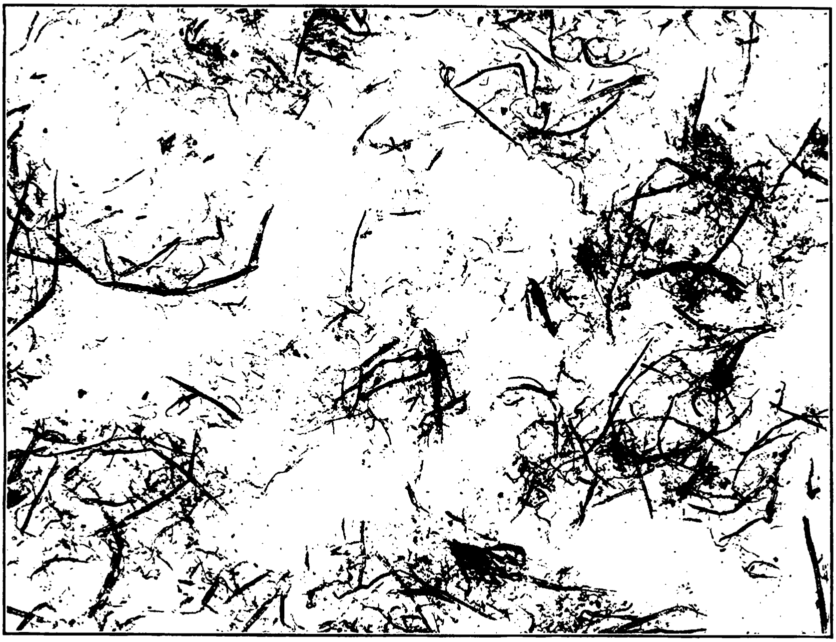

FIG. 2.—UNSTEAMED WOOD, 89.9 HORSEPOWER PER TON.

COMPARISON OF SPRUCE PULPS MADE FROM STEAMED AND UNSTEAMED WOODS.

(Magnified 15 diameters.)

## OTHER FACTORS.

### POWER CONSUMPTION PER UNIT OF STRENGTH.

Figure 19 shows the effect of the consumption of different amounts of power on the strength of paper made from the experimental pulps. It is evident that, under the present methods of manufacturing mechanical pulp, the utilization of a considerable amount of power is necessary to obtain a strong paper. The paper increases in both tensile and bursting strength with the power consumption, although not uniformly. The indications are that a maximum value of strength will be obtained at some value of power consumption, and that above this value the strength will decrease.

A factor of great importance in commercial manufacture is the power consumption per ton per meter of breaking length of paper, or, as it might also be expressed, the power consumption per ton, per point, per pound test. By dividing values of power (fig. 19) by the corresponding values of strength, results are obtained which indicate that for each horsepower expended in the manufacture of pulp at low-power consumption a greater degree of strength is obtained in the resultant paper than for a horsepower expended under conditions of high-power consumption. This fact suggests that maximum efficiency in the production of a mixed ground wood and sulphite paper of a given strength requires the proper adjustment of both the power consumption of the grinder and percentage of sulphite in the mixture. For instance, it might be desirable to use a small amount of power per ton of pulp and a relatively high proportion of sulphite, rather than a higher power consumption and lower proportion of sulphite. The proper adjustment would depend, of course, on the relative value of ground wood produced by high and low power and sulphite fiber.

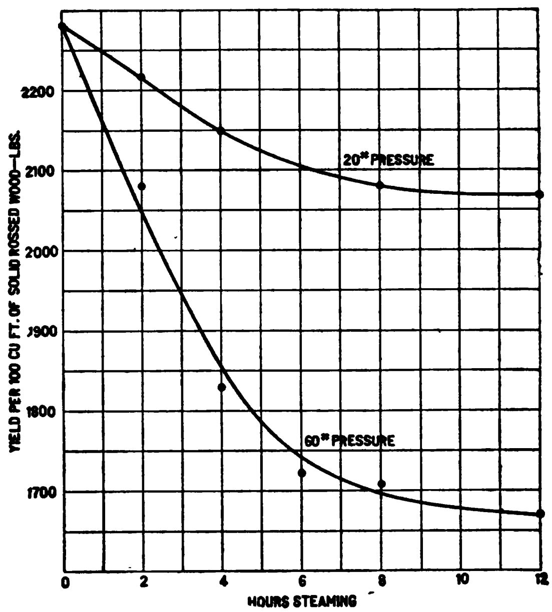


FIG. 18.—Relation of yield to length of time wood was steamed prior to grinding. (Runs Nos. 103 to 107 and 114 to 119, inclusive.)

###### SIZE OF BOLTS AND RATE OF GROWTH.

The diameter and rate of growth of the wood have very little effect upon either the power consumption or rate of production. The rate of production decreases slightly when wood of medium diameter

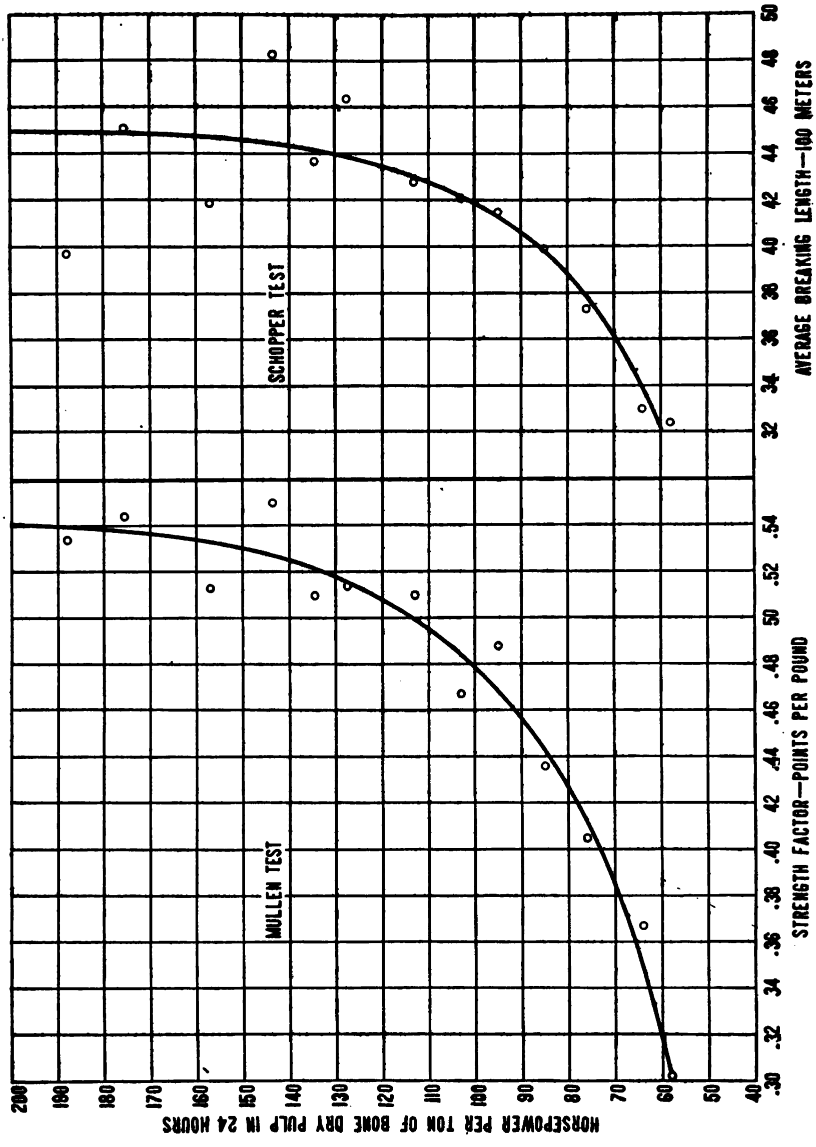


FIG. 19.—Relation of strength of paper to power consumption per ton of pulp. (Averages of all runs made.)

(6 to 8 inches) is used. This is due to the fact that in order to fill the pockets some of the wood must be split, which causes more or less binding.

The yield and quality are both influenced by the rate of growth of the wood. The yield is considerably lower from wood of rapid growth than from wood which has grown slowly. The pulp is softer when rapid-growth wood is used, although the strength is practically the same.

### EFFICIENCY OF CONVERSION.

The efficiency of converting rossed wood into pulp under ordinary commercial conditions averages approximately 88 per cent. This leaves 12 per cent of the weight of the wood to be accounted for in either screenings or white-water, or as water-soluble material. From about 2 to 7 per cent is lost in screenings and white-water as wood fiber; the remainder, 5 to 10 per cent, must be in the white-water as soluble or insoluble organic or inorganic materials. The wood when ground is in a very finely divided state and may be acted upon quite readily by the water with which it is mixed. It is reasonable to suppose that the dissolved portion would be greater under conditions of extremely hot grinding than when the cold-grinding process is used. Likewise, there would be a greater loss when the pulp remains in contact with water for a considerable period than there would be if it were immediately run out on the wet machine.

## CONCLUSIONS.

From the results of the experiments the following general conclusions are drawn:

(1) The power to grinder increases with speed and pressure of grinding and decreases with the degree of sharpness of stone. There is also a very slight increase in the power required with increase of temperature, other conditions remaining constant, while the thickness of stock in the grinder pit has almost no influence. With all other conditions similar the power to the grinder is less for steamed wood than for green or seasoned wood untreated.

(2) The rate of production varies directly with pressure, speed, and degree of sharpness of the stone. Less pulp is obtained in 24 hours with seasoned wood than with green, and still less with steamed wood, all other conditions being the same. The temperature and thickness of stock in the grinder pit have little influence on the rate of production. Slightly less pulp is produced at low temperatures.

(3) The horsepower consumption per ton, when untreated wood is ground, increases as the pressure decreases, according to a fairly definite law. It is lower on sharp stones than on dull ones and increases as the speed decreases. There is, however, not as much difference between the power consumption per ton at low speed and high speed as there is between power consumption at low pressure and high pressure. The power consumption is very little influenced

by temperature, but it is slightly lower at high temperature. The power consumption is higher for seasoned than for green wood, and higher for steamed wood than for either seasoned or green material ground under the same conditions.

(4) The yield of pulp per cord is greater at high pressure than at low, and while this is true also of the screenings there is not as much fine material lost in white water when high pressure is used. The yield is not greatly influenced by the surface of the stone, but it is slightly higher at high speed than at low. The yield is proportional to the bone-dry weight per cubic foot of wood.

(5) The quality of pulp varies most with the surface of the stone, less with the pressure, and least with the speed. The weight per cubic foot and character of wood, especially the latter, influence quality to a marked extent. Temperature also has a marked influence. Pulp of greater strength is obtained at higher temperature; that produced at low temperature will take a better finish. Pulp of better color can be obtained from green wood than from seasoned, and stronger pulp can be obtained by cooking the wood prior to grinding. The quality of paper produced under exactly the same conditions, but made of pulp produced at different grinder pressures, varies directly with the grinder pressure and the horsepower consumption per ton of pulp. Mechanical pulp of greatest strength can be produced only by the use of a relatively large amount of power.

## SUMMARY OF DATA.

A summary of the experimental data upon which the results given in this bulletin are based is given in Tables 3, 4, and 5. Tables 3 and 4 show the grinding conditions and resultant factors for untreated and for steamed wood, respectively. Table 5 gives the results of the quality test on the pulps and on the papers manufactured from them.

The following explanations apply to quantities given in Tables 3 and 4:

"Average horsepower to grinder." This is obtained by a watt-hour meter, and represents the actual consumption of power.

"Maximum horsepower to grinder." This is obtained from a recording wattmeter and represents the maximum power required by the grinder for one minute or longer at any time during the test.

"Efficiency of conversion." The efficiency of conversion is a factor obtained by dividing the yield per 100 cubic feet of solid rossed wood by the bone-dry weight per 100 cubic feet of the wood ground.

"Horsepower consumption per ton of bone-dry pulp in 24 hours." The power consumption per ton is calculated by dividing the average horsepower to the grinder by the production of bone-dry pulp in 24 hours.

The methods of computing results of the tests is explained more fully in the Forest Service publication, Experiments with Jack Pine and Hemlock for Mechanical Pulp.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp.*

| Number of mill. | Make of grinder. | Number of grinders. | How driven. | Number of pockets. | Pocket area. | Diameter of cylinders. | Approximate horse-power to grinder. | Pressure on cylinders. | Equivalent pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Stone. Kind. | Stone. Diameter. | Stone. Width of face. | Stone. Revolutions per minute. | Stone. Peripheral speed. | Temperature of grinding. | Kind of burr. | Approximate horse-power per ton. | Size of screen slots or perforations. | Kind of paper produced. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Sq. in.* | *In.* | | *Lbs. per sq. in.* | *Lbs. per sq. in.* | *Lbs.* | | *In.* | *In.* | | *Ft. per min.* | *°F.* | | | *In.* | |
| 1 | A | | | 3 | | 20 | | 35 | 71.4 | | C | 54 | 27 | 200 | 2,830 | 162 | Straight cut, 7 to inch. | 55 | | News, manila, and hanging. |
| 2 | | 6 | | 2 | 168 | 12 | 500<br>275 | 60 | 44.1 | 40.4 | | 54<br>52 | 27<br>25 | 200 | 2,830<br>2,724 | | | | | Tag, manila, and special paper. |
| 3 | A | 2 | | 3 | 336 | 16 | 300 | 35 | 45.7 | 20.95 | | 52 | 26 | 150 | 2,043 | | | | | Manila, fiber, and colored specialties. |
| 4 | B | 7 | Direct connected to water wheels. | | | | 144 | | | | | | | | | | Straight cut, 7 or 8 to inch, solid steel burr. | | | Wood-pulp board. |
| | C | 1 | do | 3 | | 16 | 300 | 50 | 65.4 | | A | 54 | 28 | 205 | 2,900 | | | 65 | 0.014 | Do. |
| 5 | D | 1 | Geared to water wheels. | 3 | | 18 | 400 | 45 | 73.4 | | B | 54 | 27 | 145 | 2,052 | | Diamond point, 6 to inch. | | .010 | News. |
| 6 | D | 2 | do | 3 | | 10 | 300 | 65 | 33.2 | | C | 54 | 27 | 219 | 3,100 | 140 | Straight pick, 8 to inch. | 31 | .010 | Do. |
| 7 | | 2 | | 3 | 144 | 14 | 500 | 50 | 50 | 53.5 | | 54 | 28 | 200 | 2,830 | | | | | Tag, manila, and special papers. |
| 8 | E | 2 | Geared to water wheels. | 3 | | 16 | 300–350 | 40 | 52 | | B and D. | 54 | 26 | 190–200 | 2,688–2,830 | 175 | Solid spiral cut, 8 to inch. | 75 | .012 | Poster, tag board, and manilas. |
| | A | 1 | do | 3 | | 16 | | 40 | 52.3 | | do | 54 | 26 | | | | | | | |
| 9 | F | 2 | Direct connected to water wheels. | | | | 300–400 | | | | | | | | | | | | | Color wrapping, and fiber. |
| 10 | A | 2 | do | | | 16 | 400 | 45–50 | 58.9–65.4 | | B | 52 | 27 | 225 | 3,064 | | Diamond point, 7 to inch. | 75 | .012 | Tissue and light weight manila. |
| | E | 1 | do | | | | 500 | | | | | | | | | | | | | |
| 11 | G | 1 | Geared to water wheels. | 3 | | | 450 | | | | | | | | | | | | | |
| 13 | | 5 | Direct connected to water wheels. | | | | | | | | | | | | | | | 70 | | News and bag. |
| | | 1 | Motor driven | | | | 300 | | | | | | | | | | | | | |

NOTE.—The characters given in the columns "Make of grinder" and "Kind" of stone indicate, respectively, which mills used the same grinder and the same stone. The actual make of the grinders and kind of stones is not given.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—Continued.

| Number of mill. | Make of grinder. | Number of grinders. | How driven. | Number of pockets. | Pocket area. | Diameter of cylinders. | Approximate horsepower to grinder. | Pressure on cylinders. | Equivalent pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Stone. Kind. | Stone. Diameter. | Stone. Width of face. | Stone. Revolutions per minute. | Stone. Peripheral speed. | Temperature of grinding. | Kind of burr. | Approximate horsepower per ton. | Size of screen slots or perforations. | Kind of paper produced. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Sq. in.* | *In.* | | *Lbs. per sq. in.* | *Lbs. per sq. in.* | *Lbs.* | | *In.* | *In.* | | *Ft. per min.* | *°F.* | | | *In.* | |
| 14 | B and C | .... | Belted to steam engine. | 3 | ...... | 14 | ....... | 40 | 40 | ..... | A | 54 | 27 | 190 | 2,688 | 80–90 | Cast steel, 5 and 6 teeth to inch; 5-inch diameter by 3-inch pick. | 85 | [1] [illegible] | News, book. |
| 15 | H | 8 | Direct connected to water wheels. | 3 | ...... | 10 | 250 | 80 | 40.8 | ..... | A | 52 | 24 | 250 | 3,405 | 100–150 | Diamond point, 6 to inch. | 70 | 0.011 | News and hanging. |
| 16 | D | 4 | do | 3 | ...... | 14 | 350 | 40 | 40 | ..... | C | 54 | 27 | 190–200 | 2,688–2,830 | Hot. | do | 75 | ........ | News. |
| | H | 15 | do | 3 | ...... | 7 | 135 | 70 | 17.5 | ..... | C | 52 | 19 | 195 | 2,660 | do. | do | ..... | ........ | |
| 17 | L | 14 | do | 3 | ...... | 16 | 450 | 45 | 58.9 | ..... | B | 50 | 27 | 220 | 2,880 | 130 | Diamond point, 9 to inch. | 75 | .075 | News, book, railroad writing. |
| 12 | ......... | .... | Geared to water wheels. | .... | ...... | .... | 400 | ..... | ......... | ..... | ...... | ..... | .... | ..... | ....... | ...... | ............ | ..... | ........ | News. |
| 18 | A | 4 | ............ | 2 | 168 | 16 | 150 | 20 | 26.2 | 24.00 | ...... | 54 | 26 | 80 | ....... | ...... | ............ | ..... | ........ | Bag and tissue. |
| 19 | E | 3 | Direct connected to water wheels. | 3 | ...... | 16 | 400 | 40 | 52.3 | ..... | B | 54 | 27 | 195 | 2,760 | 150 | Straight cut, 7 to inch. | 70 | .072 .016 | Bag, wrapping, and fiber paper. |
| 20 | ......... | 6 | Electric drive | 3 | ...... | 14 | 300 | 50 | 50 | ..... | ...... | ..... | .... | 247 | ....... | ...... | ............ | ..... | ........ | Catalogue and light-weight news. |
| | ......... | 3 | Direct connected to water wheels. | 3 | ...... | 14 | 300 | 50 | 50 | ..... | ...... | ..... | .... | 210 | ....... | ...... | ............ | ..... | ........ | |
| 21 | K | 2 | do | 3 | ...... | 16 | 125 | 12 | 17 | ..... | A | 54 | 27 | 250 | 3,540 | 150 | Straight cut, 5 or 6 to inch. | 65 | .010 | No. 1 news or No. 3 book. |
| 22 | B | 2 | Belted | 1 | ...... | 8 | 125 | 80 | 26.1 | ..... | D | 50 | 25 | 170 | 2,225 | 60 | Straight cut, 2⅜ to inch. | ..... | .013 | Cheap bristol board. |
| 23 | E | 8 | Direct connected to water wheels. | 3 | 312 | 14 | 228 | 80 | 80 | 39.5 | A | 54 | 27 | 235 | 3,322 | 120 | Straight cut, 6 to inch. | 67 | .011 | News print. |
| | E | 8 | do | 3 | 312 | 14 | 267 | 80 | 80 | ..... | A | 54 | 27 | 240 | 3,396 | 120 | ............ | 67 | .011 | Do. |
| | E | 4 | do | 3 | 312 | 14 | 487 | 80 | 80 | ..... | A | 54 | 27 | 240 | 3,396 | 120 | ............ | 67 | .011 | Do. |
| | | 1 | ............ | 2 | 560 | 14 | 267 | 80 | 80 | 22.00 | A | 54 | 27 | 240 | 3,396 | 120 | ............ | 67 | .011 | Do. |
| 24 | C | 6 | ............ | 3 | ...... | .... | 350 | 40 | ......... | ..... | ...... | 64 | 26 | 257 | 4,310 | ...... | ............ | ..... | ........ | Water fiber, bag, and manila. |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | ........ | 4 | ................ | 2 or 3 | ..... | 10 | 200 | 95 | 48.5 | .... | ....... | 54 | 19½ | ...... | ........ | ...... | ................ | .... | ....... | Hanging. |
| 26 | L....... | 2 | Direct connected to water wheels. | ..... | ..... | ... | 250 | .... | ........ | .... | ....... | 52 | 18 | ...... | ........ | ...... | ................ | .... | ....... | Coating-colored specialties, book. |
| 27 | F.B.E.M | 23 | .....do.......... | 3 | ..... | 14 | 300–400 | 60 | 60 | .... | C..... | 54 | 25½ | 215 | 3,040 | ...... | Straight cut, 7 to inch. | 100 | .075 | News. |
| 28 | M....... | 10 | .....do.......... | 3 | ..... | 16 | 350–400 | 32 | 41.8 | .... | C and D. | 55 | 27 | 200 | 2,882 | ...... | Diamond point, 6 to inch. | .... | .075 | News and light-weight manilas. |
| 29 | J....... | 5 | Geared to water wheels. | 4 | ..... | ... | 400 | .... | ........ | .... | ....... | ... | ... | ...... | ........ | ...... | ................ | .... | ....... | Printing, poster, and specialties. |
| 30 | L....... | 5 | Direct connected to motors. | .... | 360 | 16 | 400–500 | 40 | 52.3 | 22.40 | ....... | 54 | 27 | 204–240 | 2,885–3,396 | ...... | ................ | 90 | ....... | News, hanging, tablet, novel. |
| 31 | A....... | .... | ................ | 4 | ..... | 22 | ....... | 35–40 | 86.5–98.8 | .... | B..... | 54 | 27 | 190 | 2,688 | 120 | Straight cut, 8 to inch. | 100 | .010 | Wall. |
| 32 | F....... | 4 | Direct connected to water wheels. | 3 | ..... | 12 | 450 | 70 | 51.6 | .... | B..... | 54 | 27 | 180 | 2,545 | Hot. | Jig wheels....... | 63 | .012 | Hanging. |
| 33 | L....... | 1 | ................ | 3 | 384 | 16 | 300 | 45 | 58.9 | 23.60 | ....... | 54 | 27 | 195 | 2,760 | ...... | ................ | .... | ....... | Manila, building, news, board. |
| | A....... | 2 | ................ | 3 | 384 | 16 | 300 | 45 | 58.9 | 23.60 | ....... | 54 | 27 | 195 | 2,760 | ...... | ................ | .... | ....... | |
| 34 | C....... | 4 | Direct connected to water wheels. | 3 | ..... | 16 | 250 | 40 | 52.3 | .... | C..... | 54 | 27 | 225 | 3,182 | ...... | Diamond point, 8 to inch. | .... | ....... | News and manila. |
| | C....... | 1 | Geared to water wheels. | 3 | ..... | 16 | 400 | 40 | 52.3 | .... | ....... | ... | ... | ...... | ........ | ...... | ................ | .... | ....... | |
| | C....... | 1 | By electric motor. | 3 | ..... | 16 | 500 | 40 | 52.3 | .... | ....... | ... | ... | ...... | ........ | ...... | ................ | .... | ....... | |
| 35 | B....... | .... | Direct connected to water wheels. | 3 | ..... | 12 | 450 | 85 | 62.7 | .... | B..... | 54 | 26 | 225 | 3,182 | 140 | Sectional burr... | 70–75 | ....... | News and hanging. |
| 36 | B....... | 2 | ....do.......... | 3 | ..... | 8 | 300 | 110 | 35.9 | .... | D..... | 54 | 27 | 154 | 2,180 | Cold. | Diamond point, 6 to inch. | .... | .065 .010 | |
| 37 | K....... | 2 | ................ | 3 | ..... | 14 | 440 | 60 | 60 | .... | A..... | 54 | 31 | 220 | 3,114 | 150 | Sectional burr... | 70 | ....... | News. |
| | K....... | 24 | ................ | 3 | ..... | 14 | 440 | 60 | 60 | .... | A..... | 54 | 27 | 220 | 3,114 | 150 | .....do.......... | 70 | ....... | |
| | K....... | 6 | ................ | 3 | ..... | 14 | 440 | 60 | 60 | .... | A..... | 49 | 27 | 220 | 2,825 | 150 | ................ | 70 | ....... | |
| | L....... | 2 | ................ | 3 | ..... | 14 | 440 | 60 | 60 | .... | A..... | 54 | 31 | 220 | 3,115 | 150 | ................ | 70 | ....... | |
| 38 | L....... | 2 | Geared to water wheels. | 3 | ..... | 18 | 450 | 70 | 115.8 | .... | A & B. | 54 | 27 | 200 | 2,830 | ...... | Sectional straight cut, 6 and 7 to inch. | 80 | .075 | Hanging. |
| | L....... | 1 | .....do.......... | 3 | ..... | 18 | 540 | 70 | 115.8 | .... | ...do.. | 54 | 27 | 200 | 2,830 | ...... | .....do.......... | 80 | .075 | |
| 39 | E....... | 3 | ................ | 3 | 225 | 12 | 500 | 40 | 29.4 | 20.14 | ....... | 54 | 27 | 200 | 2,830 | ...... | ................ | .... | ....... | Bag and manila. |
| 40 | M....... | 2 | ................ | 3 | ..... | 14 | 480 | 50 | 50 | .... | B..... | 48 | 27 | 165 | 2,078 | ...... | Diamond point. | 80 | ....... | |
| 41 | B....... | 12 | Direct connected to water wheels. | 3 | ..... | 16 | 280 | 60 | 78.4 | .... | B & E. | 54 | 28 | 250 | 3,540 | 112 | Diamond point, 7 to inch. | 62 | .012 | News, colored fiber, book. |
| | L....... | 3 | .....do.......... | 3 | ..... | 16 | 600 | 80 | 78.4 | .... | ...do... | 54 | 28 | 250 | 3,540 | 112 | ................ | 62 | .012 | Do. |
| 42 | I....... | 1 | ................ | .... | ..... | ... | 456 | .... | ........ | .... | ....... | 42 | ... | 224 | 2,465 | ...... | ................ | 100 | ....... | |
| | N....... | 2 | ................ | .... | ..... | ... | 456 | .... | ........ | .... | ....... | 42 | ... | 120 | 1,320 | ...... | ................ | 100 | ....... | |
| 43 | ........ | 2 | ................ | 2 | 256 | 14 | 150 | 35 | 35 | 21.05 | ....... | 52 | 13 | 115 | 1,569 | ...... | ................ | .... | ....... | Covers, colored flats, specialties. |

[1] Round perforations.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—Continued.

| Number of mill. | Make of grinder. | Number of grinders. | How driven. | Number of pockets. | Pocket area. | Diameter of cylinders. | Approximate horse-power to grinder. | Pressure on cylinders. | Equivalent pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Stone. Kind. | Stone. Diameter. | Stone. Width of face. | Stone. Revolutions per minute. | Stone. Peripheral speed. | Temperature of grinding. | Kind of burr. | Approximate horse-power per ton. | Size of screen slots or perforations. | Kind of paper produced. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Sq. in.* | *In.* | | *Lbs. per sq. in.* | *Lbs. per sq. in.* | *Lbs.* | | *In.* | *In.* | | *Ft. per min.* | *° F.* | | | *In.* | |
| 44 | O | 1 | | 3 | 300 | 16 | | 50 | 65.3 | 33.50 | B | 54 | 20 | 195 | 2,760 | | Sectional cut, 8 to inch. | 105 | | Tissue and light-weight manila. |
| | L | 1 | | 3 | 300 | 16 | | 50 | 65.3 | 33.50 | B | 54 | 20 | 195 | 2,760 | | | 105 | | |
| | P | 1 | | 3 | 300 | 16 | | 50 | 65.3 | 33.50 | B | 54 | 20 | 195 | 2,760 | | | 105 | | |
| 45 | L | 4 | | 3 | 336 | 14 | 250 | 60 | 60 | 27.50 | | 54 | 27 | 120 | 1,699 | | | | | |
| 46 | M | | | 2 | | 14 | | 40 | 40 | | D | 54 | 27 | 225 | 3,182 | Hot. | Diamond point, 6 to inch. | 55 | 0.085 | Heavy board. |
| 47 | E | 4 | | 3 | 252 | 10 | 325 | 75 | 38.3 | 23.40 | | 50 | 20 | 220 | 2,880 | | | | | Boards, and milk-bottle cap stock. |
| 48 | D | 8 | Geared to water wheels. | 3 | | 12 | 275 | 38 | 27.9 | | B | 54 | 27 | 200 | 2,830 | Hot. | Diamond point. | 75 | .012 .075 | |
| 49 | D | 2 | Direct connected to water wheels. | 3 | | 10 | 150 | 80 | 40.9 | | B | 52 | 27 | 160 | 2,180 | 145 | Diamond point, 10 to inch. | 90 | | |
| | D | 3 | Geared to water wheels. | 3 | | 10 | 300 | | | | B | 52 | 27 | 160 | 2,180 | 145 | do. | 90 | | |
| 50 | L | 5 | Direct connected to water wheels. | 3 | | 16 | 475 | 35 | 45.7 | | B | 54 | 27 | 180 | 2,545 | 160 | Washers | 90 | .012 | Do not make paper. |
| 51 | B | 15 | Geared to water wheels. | 2 | | 9 | | 19 | | | B | 52 | 26½ | 190 | 2,690 | 130 | Diamond point, 7 to inch. | 70 | | |
| | J | 4 | do. | | | | | | | | | | | | | | | | | |
| 52 | L | 4 | | 3 | 416 | 16 | 410 | 40 | 52.2 | 19.32 | | 54 | 27 | 225 | 3,182 | | | | | |
| 53 | L | 4 | Direct connected to water wheels. | | | | 410 | | | | | 54 | 27 | 200 | 2,830 | | | | | Wrapping manilas, tissue, specialties. |
| 54 | | 2 | | | | 16 | | 35 | 45.7 | | | 52 | | | | | Straight cut. | | | Manila. |
| 55 | B | 6 | | 3 | 196 | 12 | 350 | | | | | 54 | 26 | | | | | | | News, manila, poster. |
| | L | 6 | | 3 | 336 | 14 | 500 | | | | | 54 | 27 | | | | | | | |
| | L | 6 | | 3 | 336 | 14 | 285 | | | | | 54 | 27 | | | | | | | |
| 56 | L | 16 | Direct connected to water wheels. | 3 | | | 283 | | | | D | 54 | | 215 | 3,040 | | | | | |
| 57 | B | 3 | do. | 2 | | 12 | 333 | 100 | 73.5 | | B | 54 | 24 | | | | | | | |
| 58 | E | 2 | | 3 | 336 | 12 | 300 | 35 | 25.7 | 11.8 | | 54 | 27 | 175 | 2,478 | | | | | Manila and tissue. |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | 2 | | 3 | | 12 | 300 | 35 | 25.7 | | | 54 | 27 | 175 | 2,478 | | | | | |
| 59 | F | 8 | Direct connected to water wheels. | 3 | | 12 | 250 | 40 | 29.4 | | Domestic and foreign. | 54 | 27 | 200 | 2,830 | 150 | Sectional cut, 5 to inch. | 80 | .055 | Pulp for news, card, manila. |
| 60a | L | 12 | do | 3 | | 14 | 350 | 45 | 45 | | A and B. | 54 | 27 | 180 | 2,545 | 150 | Diamond point cut, 8 to inch. | 95 | .014 .013 | News. |
| 60b | L | 5 | do | 3 | | 16 | 500 | 40 | 52.2 | | A | 54 | 32 | 200 | 2,830 | 177 | do | | | News, manila, fiber. |
| 61 | A | 1 | do | 3 | | 16 | | 35 | 45.7 | | A | 45 | 27 | 200 | 2,360 | Hot. | Straight cut, 8 to inch. | 125 | .065 | Bag and colored specialties. |
| 62 | B | | Direct connected to motor. | 2 | | 14 | 375 | 90 | 90 | | D | 51 | 30 | 240 | 3,204 | | Straight cut, 6 to inch. | 83 | | |
| 63 | L | 10 | Direct connected to water wheels. | 3 | | 16 | 500 | 35 | 45.7 | | | | | 200 | 2,830 | | | | | |
| | L | 3 | do | 3 | | 16 | 400 | 35 | 45.7 | | C | 54 | 28 | 200 | 2,830 | 185 | | 85 | .012 | News and manila. |
| | D | 3 | Geared to water wheels. | 3 | | 16 | 400 | 35 | 45.7 | | | | | 200 | 2,830 | | | | | |
| 64 | Q | 6 | Direct connected to water wheels. | 3 | | 12 | 275 | 59 | 43.4 | | B | 26 | 26 | | | 125 | | 75 | | News. |
| | E | 2 | do | 3 | | 12 | 275 | 59 | 43.4 | | B | | 26 | | | 125 | | 75 | | |
| 65 | C | 5 | Geared to water wheels. | 3 | | 10½ | 250 | 60 | 33.6 | | C | 54 | 27 | 160 | 2,262 | 130 | Diamond point, 7 to inch. | 80 | .065 | News and board. |
| 66 | B | 6 | Direct connected to water wheels. | 2 | | 14 | 150 | 75 | 75 | | B | 52 | 27 | 100 | 1,362 | 100 | Spiral and pick, 7 to inch. | 100 | .010 | No. 3 book. |
| 67 | A | | | 3 | | 16 | | 25 | 32.6 | | A | 54 | 27 | 200 | 2,830 | 138 | Straight cut, 6 to inch. | 80 | .010 | News. |
| 68 | R | 9 | | 2 | | | | | | | B | 48 | 20 | 125 | 1,572 | Cold. | do | | | Book and news. |
| 69 | F | 28 | Direct connected to water wheels. | 3 | | | 450 | 82 | | | | 54 | 27 | 200 | 2,830 | | | | | News, cover, wrapping. |
| 70 | F | | | 3 | | 10 | | 90 | 45.9 | | A | 54 | 26 | 200 | 2,830 | 110 | Straight cut, 6 to inch. | 75 | .011 | News. |
| 71 | S | 2 | Direct connected to water wheels. | 3 | | 8 | 400-260 | 60 | 19.6 | | B | 52 | 26 | 200 | 2,724 | Hot. | do | 100 | .012 | Tissue. |
| 72 | M | 4 | do | 3 | | 12 | | 80 | 58 | | B | 54 | 18 | 200 | 2,830 | 145 | Straight cut, 5 and 6 to inch. | 60 | .075 | Hanging, bag, news. |
| 73 | M | 2 | | | 432 | | 350 | 40 | | | | 54 | 27 | | | | | | | Manila, bag. |
| | A | 7 | | | 432 | | 350 | 40 | | | | 54 | 27 | | | | | | | |
| 74 | K | 2 | Direct connected to water wheels. | 3 | | 14 | 350 | 100 | 100 | | B | 54 | 27 | 135 | 1,910 | 150 | Diamond point, 8 to inch. | | .014 | Tag, bristol, box board, cover, wrapping. |
| | K | 2 | Geared to water wheels. | 3 | | 12 | 300 | 100 | 73.9 | | B | 54 | 27 | 135 | 1,910 | 150 | do | | .014 | |
| 75 | A | 10 | Direct connected to water wheels. | 3 | 336 | 16 | 350 | 38 | 49.6 | 22.75 | D | 54 | 26 | 200 | 2,830 | 130 | Straight cut, 8 to inch. | 60 | .075 | News and hanging. |
| | A | 4 | Motor driven | 3 | 336 | 16 | 250 | 38 | 49.6 | 22.75 | D | 54 | 26 | 200 | 2,830 | 130 | do | 60 | .075 | |
| 76 | C | 10 | | 3 | | 14 | 350 | 60 | 60 | | | 48 | 26 | 160 | 2,012 | | | | | News. |
| 77 | F | 2 | | 3 | 304 | 10 | 250 | 100 | 51 | 25.80 | | 50 | 20 | 250 | 3,275 | | | | | |
| | E | 2 | | 3 | 304 | 16 | 250 | 60 | 78.4 | 39.80 | | 52 | 20 | 250 | 3,415 | | | | | |
| 78 | K | 5 | Geared to water wheels. | 3 | | 16 | | 40 | 52.3 | | D | 54 | 27 | 225 | 3,182 | Hot. | Straight cut, 6 to inch. | 80 | .011 | Extra news. |

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—Continued.

| Number of mill. | Make of grinder. | Number of grinders. | How driven. | Number of pockets. | Pocket area. | Diameter of cylinders. | Approximate horse-power to grinder. | Pressure on cylinders. | Equivalent pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Stone. Kind. | Stone. Diameter. | Stone. Width of face. | Stone. Revolutions per minute. | Stone. Peripheral speed. | Temperature of grinding. | Kind of burr. | Approximate horse-power per ton. | Size of screen slots or perforations. | Kind of paper produced. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Sq. in.* | *In.* | | *Lbs. per sq. in.* | *Lbs. per sq. in.* | *Lbs.* | | *In.* | *In.* | | *Ft. per min.* | *° F.* | | | *In.* | |
| 79 | T....... | 6 | Direct connected to water wheels. | 3 | ...... | 14 | 300 | 45 | 45 | ..... | B..... | 54 | 26 | 185 | 2,620 | 85 | Six cut, sectional. | 70 | ........ | News and hanging. |
| 80 | A....... | ... | .................. | 3 | ...... | 16 | ....... | 80 | 104.5 | ..... | A..... | 54 | 27 | 230 | 3,255 | 70 | Straight cut, 6 to inch. | 50 | 0.010 | News. |
| 81 | ......... | 7 | .................. | 3 | 192 | 10 | 375 | 85 | 43.4 | 34.80 | ....... | 54 | 20 | 230 | 3,255 | ...... | .................. | ..... | ........ | |
| 82 | L....... | 4 | Direct connected to water wheels. | 3 | ...... | 12 | 430 | 40 | 29.6 | ..... | B..... | 54 | 18 | 240 | 3,396 | 120 | .................. | ..... | ........ | News and hanging. |
| | O....... | 2 | .....do.......... | 3 | ...... | 12 | 525 | 40 | 29.6 | ..... | B..... | 54 | 18 | 240 | 3,396 | 120 | .................. | ..... | ........ | |
| 83 | ......... | ... | .................. | 4 | ...... | 12 | ....... | 35 | 25.8 | ..... | D..... | 52 | 28 | ....... | ........... | 110 | .................. | 70 | .009 | News. |
| 84 | F....... | 4 | Direct connected to water wheels. | 3 | ...... | 12 | 420 | 70 | 51.6 | ..... | D..... | 54 | 27 | 180 | 2,545 | Above 60. | Jig wheels....... | 63 | .012 | Hanging. |
| 85 | P....... | 3 | Direct connected to water wheels | 3 | ...... | 14 | 321 | 80 | 80 | ..... | D..... | 54 | 27 | 200 | 2,830 | 110 | Straight cut, 5 to inch. | 67 | .012 | Pie plates, box board, news, book, wrapping. |
| | B....... | 2 | Belted to water wheels. | ..... | ...... | .... | 250 | ..... | ........... | ..... | ....... | ...... | ..... | ....... | ........... | ...... | .................. | ..... | ........ | |
| 86 | M....... | 4 | Direct connected to water wheels. | 3 | ...... | 12 | 400 | 40 | 29.6 | ..... | D..... | 54 | 27 | 185 | 2,620 | 108 | Straight cut, 4 to inch. | 64 | ........ | Manila, tissue. |
| 87 | C....... | 8 | Geared to water wheels. | 2 | ...... | 12 | 150 | 40 | 29.6 | ..... | B..... | 50 | 20 | 220 | 2,880 | 120 | Diamond point, 6 to inch. | 70 | .014 | News, poster, linings. |
| 88 | U....... | ... | .................. | 2 | ...... | .... | ....... | 25 | ........... | ..... | B..... | 48 | 24 | 250 | 3,140 | ...... | .................. | 65 | .016 | Tissue and special wrapping. |
| 89 | B....... | ... | .................. | 3 | ...... | 14 | ....... | 55 | 55 | ..... | A..... | 54 | 26 | 140 | 1,980 | [1] | Diamond point, 6 to inch. | 100 | .065 | Book. |
| 90a | A....... | 3 | Geared to water wheels. | 3 | ...... | 16 | 545 | ..... | ........... | ..... | B..... | 54 | 27 | 170 | 2,404 | 80 | Spiral cut, 6 to inch. | 90 | .014 | News, bag, manila, wall. |
| 90b | L....... | 4 | .....do.......... | 3 | ...... | 16 | 297 | 20 | 26.2 | ..... | B..... | 54 | 27 | 170 | 2,404 | 80 | .....do.......... | 90 | .014 | Do. |
| 90c | L....... | 7 | .....do.......... | 3 | ...... | 16 | 297 | 20 | 26.2 | ..... | B..... | 54 | 27 | 170 | 2,404 | 80 | .....do.......... | 90 | .014 | Do. |
| | A....... | 1 | .....do.......... | 3 | ...... | 16 | 297 | 20 | 26.2 | ..... | B..... | 54 | 27 | 170 | 2,404 | 80 | .....do.......... | 90 | .014 | Do. |
| 90d | L....... | 7 | .....do.......... | 3 | ...... | 16 | 255 | 20 | 26.2 | ..... | B..... | ...... | 20 | 170 | 2,404 | 80 | .....do.......... | 90 | .014 | Do. |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | D | 3 | Direct connected to water wheels. | 2 | | 11½ | | 60 | | | B | 54 | 27 | 186 | 2,632 | 149 | Straight cut, 6 to inch. | 67 | .012 | Wrapping. |
| | C | 2 | do. | | | | | | | | | | | | | | | | | |
| 92 | D | 8 | do. | 3 | | 10 | 225 | 110 | 56.1 | | C | 54 | 27 | 240 | 3,396 | 90 | Diamond point, 8 to inch. | 75 | .060 | Tag, and box board. |
| 93 | A | | | 4 | | 16 | | 45 | 58.9 | | B | 55 | 27 | 185 | 2,420 | 120 | Diamond point, 7 to inch. | | .070 | |
| 94 | D | 6 | Geared to water wheels. | | | | | | | | | | | | | | | | | Fiber and manila. |
| 95 | E | 7 | Direct connected to water wheels. | 3 | | 16 | 350 | 37 | 48.4 | | B | 54 | 26 | 180 | 2,545 | 115 | Straight cut. | 70 | .010 | News. |
| | E | 1 | Electric power | 3 | | 16 | 350 | | | | B | 54 | 26 | 180 | 2,545 | 115 | do. | 70 | .010 | Do. |
| 96 | B | 1 | Geared to water wheels. | | | | 350 | 35 | 40.1 | | | | | | | | | | | Hanging and news. |
| | B | 6 | do. | | | | 450 | 35 | 40.1 | | | | | | | | | | | |
| | F | 1 | do. | 3 | | 15 | 500 | 35 | 40.1 | | D | 54 | 27 | 250 | 3,540 | 140 | Straight cut, sectional, 5 to inch. | 90 | .089 | News. |
| | B | 3 | Direct connected to water wheels. | | | | 350 | 35 | 40.1 | | | | | | | | | | | |
| | C | 4 | do. | 3 | | 15 | 375 | 35 | 40.1 | | | | | | | | | | | |
| 97 | D | | | 3 | | 7 | 300 | 95 | 23.8 | | C | 50 | 27 | | | | | | | Manila wrapping. |
| 98 | F | | Direct connected to water wheels. | 3 | | 12 | 275 | 75–80 | 55.4–59 | | B | 52 | 27 | 180 | 2,455 | 90 | Straight cut, 4 to inch. | 50 | .015 | Colored fiber and express. |
| 99 | K | | | 3 | | 16 | | 42 | 54.9 | | B | 48 | 27 | 230 | 2,892 | 155 | Sectional cut, 6 to inch. | 65 | | News. |
| 100 | L | 2 | | 3 | | 16 | 300 | 40 | 52.3 | | B | 54 | 27 | 215 | 3,042 | | do. | | | |
| 101 | L | 6 | Direct connected to water wheels. | 3 | | 16 | 350 | 16 | 20.9 | | B | 52 | 26 | 135 | 1,840 | 140 | 5 threads to inch. | 70 | | Bag and manila wrapping. |
| 102 | F | | | 3 | | 12 | | 60 | 44.3 | | B | 52 | 27 | 180 | 2,454 | 212 | Diamond point, 9 to inch. | 80 | | Print paper and manilas. |
| 103 | V | | | 6 | | | 1,500 | (2) | | | D | 52 | 18 | 195 | 2,660 | 110 | Hand picked. | | | |
| 104 | K | 16 | | 3 | 434 | 16 | 625 | 55 | 71.9 | | | 54 | 30 | 250 | 3,540 | | | | | News. |
| 105 | | 3 | | 3 | 224 | 16 | | 50 | 65.3 | | | 54 | 28 | 200 | 2,830 | | | | | Do. |
| 106 | A | 10 | | 4 | | 16 | 405 | 25–30 | 32.6–38.2 | | | 54 | 27 | 200 | 2,830 | | | | | News, manila, bag, tissue, wrapping, sheathing, and hanging. |
| | A | 6 | | 4 | | 16 | 405 | 40 | 52.3 | | | 54 | 27 | 210 | 2,970 | | | | | |
| | A | 3 | | 4 | | 16 | 500 | 35–40 | 45.7–52.3 | | | 54 | 27 | 240 | 3,396 | | | | | |
| | F | 2 | | 3 | | 10 | 353 | 65 | 33.2 | | | 54 | 27 | 250 | 3,540 | | | | | |
| | A | 4 | | 4 | | | 400 | | | | | 54 | 26 | 200 | 2,830 | | | | | |
| 107 | M | 1 | | 3 | 312 | 14 | 300 | 35 | 35 | | | 54 | 28 | 250 | 3,540 | | | | | Tissue. |
| 108 | F | 57 | | 3 | | 12 | 350 | 60 | 44 | | | 54 | 27 | 200–225 | 2,830<br>3,182 | | | | | News. |

[1] Ordinary.

[2] Mechanical feed.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated.*

| Wood shipment No. | Run number. | Kind of burr. | Surface of stone. | Pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Revolutions per minute. | Peripheral speed. | Average horsepower to grinder. | Maximum horsepower to grinder. | Bone-dry pulp in 24 hours. | Horsepower per ton bone-dry pulp in 24 hours. | Solid rossed wood ground in 24 hours. | Weight per cubic foot bone-dry wood. | Average diameter of wood. | Moisture in wood. | Bone-dry pulp per 100 cubic feet solid rossed wood. | Efficiency of conversion. | Screenings per 100 cubic feet solid rossed wood bone-dry. | Stock in white water per 100 cubic feet solid rossed wood bone-dry. | Average temperature of grinding. | Horsepower ÷ pressure × speed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Lbs. per sq. in.* | *Lbs.* | | *Ft. per min.* | | | *Tons.* | | *Cu. ft.* | *Lbs.* | *In.* | *P. ct.* | *Lbs.* | *P. ct.* | *Lbs.* | *Lbs.* | *° F.* | |
| W-10[1] | [2] 1 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Freshly dressed | 40,50 | 16.4 / 20.5 | 175 | 2,445 | 403 | | 4.988 | 80.8 | | | | | | | | | 171 | |
| W-10[1] | [2] 1 | do | Same, not re-dressed. | 40,50 | 16.4 / 20.5 | 175 | 2,445 | 399 | | 4.525 | 88.1 | | | | | | | | | 175.5 | |
| Weighted averages. | | | | 40,50 | 16.4 / 20.5 | 175 | 2,445 | 401 | | 4.810 | 83.5 | 386.2 | 28.4 | | 28.90 | 2,480 | 87.4 | 17.2 | | 172.6 | |
| W-9[1] | [2] 2 | Straight cut, 3 to inch; Spiral cut, 12 to inch. | Freshly dressed | 40 | 16.4 | 200 | 2,795 | 398 | | 4.245 | 93.8 | | | | | | | | | 164.3 | 0.00991 |
| W-9[1] | [2] 2 | do | Same, not re-dressed. | 40 | 16.4 | 200 | 2,795 | 408 | | 3.995 | 102.0 | | | | | | | | | 171.3 | .01017 |
| W-9[1] | [2] 2 | do | do | 40 | 16.4 | 200 | 2,795 | 394 | | 4.175 | 94.4 | | | | | | | | | 166.7 | .00981 |
| Weighted averages. | | | | 40 | 16.4 | 200 | 2,795 | 402 | | 4.120 | 97.5 | 409.5 | 22.72 | | 39.33 | 2,012 | 88.5 | 13.75 | | 168.0 | .01002 |
| W-10[1] | 3 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Freshly dressed | 20 | 8.2 | 175 | 2,445 | 191 | 215 | 1.215 | 157.0 | 105.4 | 27.66 | | 30.14 | 2,300 | 83.2 | 9.82 | | 163.0 | .00954 |
| W-10[1] | 4 | do | Same, not re-dressed. | 40 | 16.4 | 175 | 2,445 | 333 | 388 | 3.025 | 110.0 | 251.3 | 27.66 | | 30.14 | 2,408 | 87.1 | 17.80 | | 166.5 | .00830 |
| W-10[1] | 5 | do | do | 60 | 24.65 | 175 | 2,445 | 454 | 506 | 5.255 | 86.4 | 436 | 27.66 | | 30.14 | 2,415 | 87.3 | 18.60 | | 152.2 | .00753 |
| W-10[1] | 6 | do | do | 20 | 8.2 | 225 | 3,145 | 225 | 264 | 1.198 | 188.0 | 106.2 | 27.66 | | 30.14 | 2,255 | 81.5 | 9.66 | | 179.8 | .00873 |
| W-10[1] | 7 | do | do | 40 | 16.4 | 225 | 3,145 | 412 | 494 | 3.775 | 109.0 | 314 | 27.66 | | 30.14 | 2,404 | 87.0 | 10.15 | | 163.8 | .00799 |
| W-10[1] | 8 | do | do | 60 | 24.65 | 225 | 3,145 | 567 | 651 | 6.215 | 91.2 | 474.5 | 27.66 | | 30.14 | 2,624 | 95.0 | 15.70 | | 158.3 | .00731 |
| W-10[1] | 9 | Spiral cut, 6 to inch. | Freshly dressed | 20 | 8.2 | 175 | 2,442 | 174.7 | 222 | .995 | 175.5 | 93.7 | 27.66 | | 30.14 | 2,122 | 76.8 | 13.54 | | 165.5 | .008715 |
| W-10[1] | 9-1 | do | Same as for No. 14. | 20 | 8.2 | 175 | 2,442 | 178.5 | 212 | 1.910 | 93.5 | 166.4 | 27.52 | | 29.29 | 2,295 | 83.5 | 12.60 | | 144.2 | .00891 |
| W-10[1] | 10 | do | Freshly dressed | 40 | 16.4 | 175 | 2,442 | 287 | 357 | 3.850 | 74.5 | 311.0 | 27.66 | | 30.14 | 2,478 | 89.5 | 21.10 | | 139.2 | .007155 |
| W-10[1] | 11 | do | Same, not re-dressed. | 60 | 24.65 | 175 | 2,442 | 397 | 480 | 6.060 | 65.5 | 505 | 27.66 | | 30.14 | 2,400 | 86.8 | 56.5 | | 142.2 | .00659 |
| W-10[1] | 12 | do | do | 20 | 8.2 | 225 | 3,140 | 225 | 280 | 2.995 | 75.2 | 216.6 | 27.66 | | 30.14 | 2,302 | 83.3 | 19.57 | | 154.0 | .00874 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W-10[1]..... | 13 | .....do.......... | .....do........... | 40 | 16.4 | 225 | 3,140 | 356 | 431 | 5.305 | 67.2 | 431 | 27.90 | .... | 29.90 | 2,464 | 88.7 | 16.75 | ...... | 137.0 | .00691 |
| W-10[1]..... | 14 | .....do.......... | .....do........... | 60 | 24.65 | 225 | 3,140 | 508 | 586 | 7.840 | 64.9 | 654 | 28.11 | .... | 29.04 | 2,400 | 85.4 | 30.95 | ...... | 135.7 | .00656 |
| W-10[1]..... | 15 | Diamond point, 8 to inch. | Freshly dressed... | 20 | 8.2 | 175 | 2,442 | 183 | 210 | 1.435 | 127.6 | 120.3 | 27.52 | .... | 29.29 | 2,390 | 81.9 | 11.05 | ...... | 163 | .00913 |
| W-10[1]..... | 16 | .....do.......... | Same, not re-dressed. | 40 | 16.4 | 175 | 2,442 | 327 | 388 | 3.705 | 88.2 | 326 | 27.59 | .... | 27.81 | 2,272 | 82.4 | 13.20 | ...... | 147 | .00815 |
| W-10[1]..... | 17 | .....do.......... | .....do........... | 60 | 24.65 | 175 | 2,442 | 426 | 489 | 5.340 | 79.8 | 455 | 27.59 | $6\frac{1}{8}$ | 27.81 | 2,345 | 85.0 | 9.84 | ...... | 141 | .00707 |
| W-10[1]..... | 18 | .....do.......... | .....do........... | 20 | 8.2 | 225 | 3,140 | 234 | 287 | 2.088 | 112.0 | 181 | 27.59 | $5\frac{3}{4}$ | 27.81 | 2,307 | 83.7 | 7.75 | ...... | 158.2 | .00909 |
| W-10[1]..... | 19 | .....do.......... | .....do........... | 40 | 16.4 | 225 | 3,140 | 379 | 441 | 4.220 | 89.8 | 359 | 27.59 | 6 | 27.81 | 2,350 | 85.2 | 12.60 | ...... | 151.8 | .00735 |
| W-10[1]..... | 20 | .....do.......... | .....do........... | 60 | 24.65 | 225 | 3,140 | 521 | 592 | 6.360 | 82.0 | 534.5 | 29.12 | $5\frac{1}{8}$ | 27.32 | 2,380 | 81.8 | 11.50 | ...... | 148.6 | .006735 |
| W-10[1]..... | 21 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Freshly dressed... | 40 | 16.4 | 175 | 2,442 | 312 | 378 | 2.155 | 144.8 | 200 | 27.80 | $3\frac{5}{8}$ | 27.42 | 2,155 | 77.5 | 7.45 | ...... | 170.8 | .00778 |
| W-10[1]..... | 22 | .....do.......... | Same, not re-dressed. | 40 | 16.4 | 175 | 2,442 | 321 | 365 | 2.260 | 142 | 197.5 | 28.34 | $8\frac{3}{4}$ | 27.57 | 2,290 | 80.8 | 7.73 | ...... | 171.5 | .00800 |
| W-9[1]..... | 23 | .....do.......... | .....do........... | 40 | 16.4 | 175 | 2,442 | 324 | 372 | 2.415 | 134 | 267.5 | 21.08 | 14 | 37.74 | 1,820 | 86.3 | 7.84 | ...... | 163.1 | .008085 |
| W-10[1]..... | 24 | .....do.......... | Freshly dressed... | 60 | 24.65 | 100 | 1,398 | 299 | 359 | 3.005 | 99.5 | 255 | 27.60 | $5\frac{3}{4}$ | 31.70 | 2,360 | 85.5 | 12.90 | ...... | 140.2 | .00867 |
| W-10[1]..... | 25 | .....do.......... | Same, not re-dressed. | 60 | 24.65 | 150 | 2,093 | 416 | 478 | 4.655 | 89.4 | 382 | 29.05 | $5\frac{5}{8}$ | 27.90 | 2,440 | 84.0 | 20.00 | ...... | 149.5 | .00807 |
| W-10[1]..... | 26 | .....do.......... | .....do........... | 60 | 24.65 | 200 | 2,792 | 529 | 605 | 5.960 | 88.7 | 481.6 | 29.05 | $5\frac{5}{8}$ | 27.90 | 2,476 | 85.1 | 20.06 | ...... | 149.3 | .00768 |
| W-10[1]..... | 27 | .....do.......... | .....do........... | 60 | 24.65 | 250 | 3,490 | 640 | 731 | 7.850 | 81.5 | 675 | 27.02 | 5 | 28.40 | 2,326 | 86.0 | 11.00 | ...... | 138.6 | .00743 |
| W-10[1]..... | 28 | .....do.......... | .....do........... | 30 | 12.3 | 250 | 3,490 | 350 | 397 | 2.938 | 119.2 | 251.5 | 28.68 | $5\frac{5}{8}$ | 30.40 | 2,340 | 81.5 | 8.54 | ...... | 163.2 | .00811 |
| W-10[1]..... | 29 | .....do.......... | .....do........... | 40 | 16.4 | 188 | 2,624 | 355 | 428 | 2.950 | 120.3 | 247 | 28.68 | $5\frac{3}{4}$ | 30.40 | 2,390 | 83.3 | 11.20 | ...... | 171.3 | .00824 |
| W-10[1]..... | 29-1 | .....do.......... | Same as for No. 31. | 40 | 16.4 | 188 | 2,624 | 343 | 407 | 2.685 | 127.7 | 236.2 | 27.24 | $5\frac{5}{8}$ | 28.30 | 2,275 | 83.5 | 10.27 | ...... | 172.8 | .00796 |
| W-10[1]..... | 30 | .....do.......... | Same as for No. 29. | 50 | 20.5 | 150 | 2,093 | 356 | 391 | 3.850 | 92.5 | 318 | 26.88 | $5\frac{5}{8}$ | 31.00 | 2,420 | 90.0 | 9.94 | ...... | 146.3 | .00830 |
| W-10[1]..... | 31 | .....do.......... | Same, not re-dressed. | 60 | 24.65 | 125 | 1,745 | 358 | 398 | 3.580 | 100.0 | 306 | 26.88 | $5\frac{7}{8}$ | 31.00 | 2,340 | 87.0 | 15.00 | ...... | 151.0 | .008315 |
| W-10[1]..... | 32 | .....do.......... | Freshly dressed... | 30 | 12.3 | 250 | 3,470 | 314 | 385 | 5.200 | 60.4 | 441.5 | 27.24 | $5\frac{3}{8}$ | 28.30 | 2,355 | 86.6 | 13.20 | ...... | 124.4 | .00736 |
| W-10[1]..... | 33 | .....do.......... | Same, not re-dressed. | 35 | 14.36 | 214 | 2,970 | 344 | 404 | 6.040 | 57.0 | 505 | 27.24 | $5\frac{7}{8}$ | 28.30 | 2,390 | 87.8 | 12.05 | ...... | 131.5 | .00806 |
| W-10[1]..... | 34 | .....do.......... | .....do........... | 40 | 16.4 | 188 | 2,609 | 320.5 | 389 | 5.290 | 60.6 | 452 | 27.24 | $5\frac{1}{8}$ | 28.30 | 2,338 | 85.8 | 14.18 | ...... | 123.2 | .00749 |
| W-10[1]..... | 35 | .....do.......... | .....do........... | 45 | 18.46 | 167 | 2,318 | 341 | 392 | 5.255 | 64.9 | 444 | 27.35 | $5\frac{1}{2}$ | 29.98 | 2,370 | 86.6 | 10.48 | ...... | 128.0 | .007975 |
| W-10[1]..... | 36 | .....do.......... | Same as for No. 35. | 50 | 20.5 | 150 | 2,081 | 339 | 399 | 5.230 | 64.8 | 445 | 27.35 | $5\frac{1}{2}$ | 29.98 | 2,355 | 86.1 | 13.22 | ...... | 127.4 | .00795 |
| W-10[1]..... | 37 | .....do.......... | Same, not re-dressed. | 55 | 22.6 | 136 | 1,887 | 328 | 381 | 5.200 | 63.1 | 432 | 27.35 | $5\frac{3}{4}$ | 29.98 | 2,410 | 88.1 | 18.96 | ...... | 129.5 | .00770 |
| W-10[1]..... | 38 | .....do.......... | .....do........... | 60 | 24.65 | 125 | 1,734 | 327 | 380 | 4.870 | 67.1 | 428 | 27.35 | $5\frac{7}{8}$ | 29.98 | 2,280 | 83.4 | 21.80 | ...... | 131.7 | .00765 |
| W-10[1]..... | 39 | .....do.......... | Freshly dressed... | 50 | 20.5 | 200 | 2,775 | 429 | 495 | 5.875 | 73.0 | 502 | 27.60 | $5\frac{1}{2}$ | 31.40 | 2,340 | 84.8 | 13.20 | ...... | 86.0 | .00754 |
| W-10[1]..... | 40 | .....do.......... | Same, not re-dressed. | 50 | 20.5 | 200 | 2,775 | 400.5 | 481 | 5.240 | 76.5 | 434 | 27.60 | $5\frac{1}{2}$ | 31.40 | 2,418 | 87.6 | 13.13 | ...... | 116.6 | .00704 |
| W-10[1]..... | 41 | .....do.......... | .....do........... | 50 | 20.5 | 200 | 2,775 | 453 | 515 | 6.210 | 72.9 | 529 | 27.60 | $5\frac{1}{8}$ | 31.40 | 2,350 | 85.2 | 17.92 | ...... | 159.3 | .00797 |
| W-10[1]..... | 42 | .....do.......... | .....do........... | 20 | 8.2 | 175 | 2,428 | 164 | 183 | 1.640 | 101.2 | 132 | 28.35 | $5\frac{5}{8}$ | 33.25 | 2,455 | 86.5 | 6.83 | ...... | 85.0 | .00824 |
| W-10[1]..... | 43 | .....do.......... | .....do........... | 40 | 16.4 | 175 | 2,428 | 315.5 | 366 | 3.110 | 101.3 | 252 | 28.35 | 5 | 33.25 | 2,470 | 87.0 | 7.98 | ...... | 87.8 | .00792 |
| W-10[1]..... | 44 | .....do.......... | .....do........... | 60 | 24.65 | 175 | 2,428 | 442 | 526 | 5.145 | 86.0 | 392 | 28.35 | 6 | 33.25 | 2,620 | 92.4 | 13.12 | ...... | 86.7 | .00739 |
| W-10[1]..... | 45 | .....do.......... | .....do........... | 20 | 8.2 | 175 | 2,428 | 177.7 | 209 | 1.105 | 116.7 | 89.1 | 28.35 | $5\frac{7}{8}$ | 33.25 | 2,480 | 87.5 | 11.90 | ...... | 176.3 | .00892 |
| W-9[1]..... | 46 | .....do.......... | .....do........... | 40 | 16.4 | 175 | 2,428 | 323 | 360 | 3.410 | 94.7 | 350 | 22.40 | $6\frac{1}{4}$ | 44.00 | 1,950 | 87.0 | 9.50 | ...... | 152.7 | .00778 |
| W-9[1]..... | 47 | .....do.......... | .....do........... | 60 | 24.65 | 175 | 2,428 | 449 | 531 | 5.610 | 79.9 | 582 | 22.40 | $6\frac{1}{2}$ | 44.00 | 1,930 | 86.1 | 15.83 | ...... | 145.0 | .00719 |
| W-9[1]..... | 48 | .....do.......... | .....do........... | 20 | 8.2 | 175 | 2,428 | 176.8 | 222 | 1.350 | 131.0 | 144.6 | 22.40 | $6\frac{5}{8}$ | 44.00 | 1,870 | 83.5 | 3.48 | ...... | 86.4 | .00888 |
| W-9[1]..... | 49 | .....do.......... | .....do........... | 40 | 16.4 | 175 | 2,428 | 320 | 406 | 2.820 | 113.5 | 289 | 22.40 | 6 | 44.00 | 1,952 | 87.2 | 8.45 | ...... | 86 | .00803 |
| W-9[1]..... | 50 | .....do.......... | .....do........... | 60 | 24.65 | 175 | 2,428 | 435 | 487 | 4.680 | 93.0 | 461 | 22.40 | $6\frac{1}{2}$ | 44.00 | 2,030 | 90.6 | 9.22 | ...... | 89.3 | .00726 |
| W-17[1]..... | [3]52 | .....do.......... | Freshly dressed... | 20 | 8.2 | 225 | 3,107 | 148 | 160 | .816 | 181.2 | 80 | 26.61 | $5\frac{5}{8}$ | 24.14 | 2,040 | 76.6 | 6.65 | ...... | 171.3 | .00581 |

[1] Seasoned. [2] Commercial. [3] Wood was ground in two pockets at a time.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated*—Continued.

| Wood shipment No. | Run number. | Kind of burr. | Surface of stone. | Pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Revolutions per minute. | Peripheral speed. | Average horsepower to grinder. | Maximum horsepower to grinder. | Bone-dry pulp in 24 hours. | Horsepower per ton bone-dry pulp in 24 hours. | Solid rossed wood ground in 24 hours. | Weight per cubic foot bone-dry wood. | Average diameter of wood. | Moisture in wood. | Bone-dry pulp per 100 cubic feet solid rossed wood. | Efficiency of conversion. | Screenings per 100 cubic feet solid rossed wood bone-dry. | Stock in white water per 100 cubic feet solid rossed wood bone-dry. | Average temperature of grinding. | Horsepower ÷ pressure × speed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Lbs. per sq. in.* | *Lbs.* | | *Ft. per min.* | | | *Tons.* | | *Cu. ft.* | *Lbs.* | *In.* | *P. ct.* | *Lbs.* | *P. ct.* | *Lbs.* | *Lbs.* | *° F.* | |
| W-17[1]..... | [4]53 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Same, not re-dressed. | 40 | 16.4 | 225 | 3,107 | 282 | 334 | 2.695 | 104.7 | 249 | 26.61 | 6¾ | 24.14 | 2,160 | 81.1 | 9.70 | ...... | 159.3 | 0.00553 |
| W-17[1]..... | [4]54 | .....do.......... | .....do.......... | 60 | 24.65 | 225 | 3,107 | 394 | 447 | 5.770 | 68.3 | 519 | 26.34 | 4⅝ | 25.12 | 2,225 | 84.5 | 11.40 | ...... | 137.8 | .00514 |
| W-17[1]..... | [4]55 | .....do.......... | .....do.......... | 80 | 32.8 | 225 | 3,107 | 497 | 551 | 8.340 | 59.6 | 738 | 26.34 | 4⅝ | 25.12 | 2,258 | 85.7 | 15.85 | ...... | 136.3 | .00487 |
| W-17[1]..... | [4]56 | .....do.......... | .....do.......... | 100 | 41.0 | 225 | 3,107 | 556 | 621 | 9.770 | 57.0 | 860 | 26.34 | 5⅝ | 25.12 | 2,272 | 86.2 | 20.24 | ...... | 133.7 | .00436 |
| W-17[1]..... | [4]58 | .....do.......... | Freshly dressed... | 40 | 16.4 | 250 | 3,452 | 285 | 326 | 4.600 | 62.0 | 403 | 26.34 | 6¼ | 25.12 | 2,280 | 86.6 | 7.35 | ...... | 139.1 | .00504 |
| W-17[1]..... | [4]59 | .....do.......... | Same, not re-dressed. | 60 | 24.65 | 250 | 3,452 | 426 | 460 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | .00500 |
| W-17[1]..... | 60 | .....do.......... | Freshly dressed... | 40 | 16.4 | 100 | 1,381 | 194 | 242 | 2.110 | 92.0 | 190 | 27.11 | 5 | 25.31 | 2,220 | 81.9 | 9.43 | ...... | 141.5 | .00856 |
| W-17[1]..... | 61 | .....do.......... | Same, not re-dressed. | 40 | 16.4 | 150 | 2,071 | 275 | 318 | 3.005 | 91.5 | 271 | 25.03 | 4¾ | 30.54 | 2,218 | 88.5 | 11.16 | ...... | 146.8 | .00810 |
| W-17[1]..... | 62 | .....do.......... | .....do.......... | 40 | 16.4 | 200 | 2,762 | 354 | 427 | 4.080 | 86.7 | 358 | 25.03 | 5½ | 30.54 | 2,280 | 91.0 | 8.50 | ...... | 143.9 | .00781 |
| W-17[1]..... | 63 | .....do.......... | .....do.......... | 40 | 16.4 | 250 | 3,452 | 407 | 460 | 4.980 | 81.8 | 439 | 25.03 | 5½ | 30.54 | 2,270 | 90.6 | 7.91 | ...... | 144.1 | .00720 |
| W-17[1]..... | 64 | .....do.......... | .....do.......... | 60 | 24.65 | 100 | 1,381 | 275 | 322 | 3.500 | 78.6 | 303 | 25.72 | 5¼ | 28.83 | 2,310 | 89.9 | 18.27 | ...... | 141.1 | .00806 |
| W-17[1]..... | 65 | .....do.......... | .....do.......... | 60 | 24.65 | 150 | 2,071 | 362 | 419 | 4.500 | 80.5 | 398 | 25.72 | 5¼ | 28.83 | 2,262 | 88.0 | 11.82 | ...... | 137.7 | .00709 |
| W-17[1]..... | 66 | .....do.......... | .....do.......... | 60 | 24.65 | 200 | 2,762 | 481 | 560 | 5.800 | 83.0 | 505 | 25.72 | 5⅝ | 28.83 | 2,298 | 89.3 | 12.32 | ...... | 143.0 | .00706 |
| W-17[1]..... | 67 | .....do.......... | .....do.......... | 60 | 24.65 | 250 | 3,452 | 546 | 620 | 7.335 | 74.5 | 675 | 25.08 | 5¼ | 27.64 | 2,170 | 86.5 | 13.53 | ...... | 140.0 | .00641 |
| W-17[1]..... | [4]68 | .....do.......... | .....do.......... | 40 | 16.4 | 250 | 3,452 | 304 | 350 | 3.715 | 81.8 | 336 | 25.88 | 6¼ | 27.34 | 2,210 | 85.4 | 7.22 | ...... | 144.8 | .00536 |
| W-17[1]..... | [4]69 | .....do.......... | .....do.......... | 60 | 24.65 | 250 | 3,452 | 401 | 431 | 5.590 | 71.8 | 489 | 25.88 | 5⅝ | 27.34 | 2,280 | 88.1 | 10.22 | ...... | 138.8 | .00471 |
| W-17[1]..... | [4]70 | .....do.......... | .....do.......... | 80 | 32.8 | 250 | 3,452 | 510 | 564 | 8.100 | 63.0 | 709 | 25.94 | 5¼ | 28.40 | 2,285 | 88.1 | 13.28 | ...... | 134.6 | .00450 |
| W-18[1]..... | [4]71 | .....do.......... | .....do.......... | 100 | 41.0 | 250 | 3,452 | 543 | 661 | 8.930 | 60.8 | 780 | 26.15 | 6 | 32.38 | 2,288 | 87.5 | 11.26 | ...... | 129.2 | .00384 |
| W-18[2]..... | [3]74 | .....do.......... | Same as for No. 73[3]. | 60 | 24.65 | 175 | 2,417 | 451.5 | 502 | 5.025 | 89.9 | 492 | 27.09 | 6½ | 39.70 | 2,042 | 75.5 | 9.90 | ...... | 145.4 | .00760 |
| W-18[2]..... | 75 | .....do.......... | Same, not re-dressed. | 40 | 16.4 | 175 | 2,417 | 330 | 367 | 2.900 | 113.8 | 275 | 27.09 | 7 | 39.70 | 2,110 | 77.9 | 7.60 | ...... | 149.2 | .00833 |
| W-18[2]..... | 76 | .....do.......... | .....do.......... | 20 | 8.2 | 175 | 2,417 | 185.7 | 239 | .987 | 188.0 | 98.5 | 27.09 | 6¾ | 39.70 | 2,004 | 74.1 | 5.67 | ...... | 174.1 | .00938 |
| W-18[1]..... | 80 | .....do.......... | Same as for No. 79[3]. | 20 | 8.2 | 175 | 2,417 | 183 | 239 | .640 | 286 | 63.5 | 27.47 | 5⅝ | 28.33 | 2,016 | 74.3 | 10.43 | ...... | 181.8 | .00925 |
| W-18[1]..... | 81 | .....do.......... | Same, not re-dressed. | 40 | 16.4 | 175 | 2,417 | 334 | 392 | 2.525 | 132.2 | 237 | 27.47 | 5⅝ | 28.33 | 2,125 | 77.4 | 10.40 | ...... | 161.2 | .00843 |
| W-18[1]..... | 82 | .....do.......... | .....do.......... | 60 | 24.65 | 175 | 2,417 | 449 | 527 | 4.590 | 97.8 | 413 | 27.47 | 5⅝ | 28.33 | 2,220 | 80.8 | 15.07 | ...... | 148.0 | .00754 |
| W-18[2]..... | 83 | .....do.......... | Same as for No. 82. | 60 | 24.65 | 100 | 1,381 | 281 | 323 | 2.850 | 98.6 | 269 | 27.09 | 7½ | 39.70 | 2,120 | 78.2 | 15.05 | ...... | 148.1 | .00824 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W-18[2]..... | 84 | .....do.......... | Same, not redressed. | 60 | 24.65 | 150 | 2,072 | 414 | 467 | 3.530 | 117.2 | 309 | 27.12 | 6¼ | 37.56 | 2,284 | 84.4 | 20.50 | ...... | 155.8 | .00810 |
| W-18[2]..... | 85 | .....do.......... | .....do.......... | 60 | 24.65 | 200 | 2,762 | 495 | 550 | 5.350 | 92.6 | 481 | 27.12 | 6½ | 37.56 | 2,220 | 81.9 | 14.21 | ...... | 148.7 | .00726 |
| W-18[2]..... | 86 | .....do.......... | .....do.......... | 60 | 24.65 | 250 | 3,452 | 608 | 677 | 6.875 | 88.4 | 686 | 26.38 | 8 | 40.15 | 2,004 | 76.1 | 10.40 | ...... | 143.6 | .00714 |
| W-18[2]..... | [4] 87 | .....do.......... | .....do.......... | 40 | 16.4 | 250 | 3,452 | 315 | 358 | 2.600 | 121.1 | 260 | 26.38 | 7½ | 40.15 | 2,000 | 75.9 | 6.14 | ...... | 161 | .00556 |
| W-18[2]..... | [4] 88 | .....do.......... | .....do.......... | 60 | 24.65 | 250 | 3,452 | 439 | 485 | 3.840 | 114.2 | 405 | 25.15 | 7¾ | 41.24 | 1,893 | 75.4 | 10.46 | ...... | 169 | .00515 |
| W-18[2]..... | [4] 89 | .....do.......... | .....do.......... | 80 | 32.8 | 250 | 3,452 | 560 | 609 | 6.520 | 85.9 | 675 | 25.15 | 6½ | 41.24 | 1,932 | 77.0 | 13.18 | ...... | 147.6 | .00495 |
| W-18[2]..... | [4] 90 | .....do.......... | .....do.......... | 100 | 41.0 | 250 | 3,452 | 640 | 699 | 8.140 | 78.6 | 823 | 25.15 | 6¼ | 41.24 | 1,978 | 78.7 | 13.59 | ...... | 150.3 | .00452 |
| W-18[2]..... | 91 | .....do.......... | .....do.......... | 54 | 22.15 | 250 | 3,452 | 554 | 610 | 4.755 | 116.4 | 482 | 25.15 | 6½ | 41.24 | 1,972 | 78.5 | 9.25 | ...... | 161.1 | .00725 |
| W-18[1]..... | 92 | Diamond point, cut 6 to the inch. | Freshly dressed... | 100 | 41.0 | 250 | 3,452 | 650 | 723 | ...... | ...... | ...... | 27.51 | 6½ | 27.47 | ...... | ...... | ...... | ...... | 126.5 | .00460 |
| W-18[1]..... | 93 | Diamond point, cut 6 to inch. | Same, not redressed. | 20 | 8.2 | 250 | 3,452 | 276.5 | 286 | ...... | ...... | ...... | 27.51 | 6½ | 27.47 | ...... | ...... | ...... | ...... | 136.0 | .00906 |
| W-18[1]..... | 94 | Spiral cut, 6 to inch. | Freshly dressed... | 100 | 41.0 | 250 | 3,435 | 572.5 | 653 | ...... | ...... | ...... | 27.51 | 5⅝ | 27.47 | ...... | ...... | ...... | ...... | 107.6 | .00407 |
| W-18[1]..... | 95 | .....do.......... | Same, not redressed. | 20 | 8.2 | 250 | 3,435 | 232.5 | 278 | ...... | ...... | ...... | 27.51 | 5⅝ | 27.47 | ...... | ...... | ...... | ...... | 110.6 | .00826 |
| W-18[1]..... | 96 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Freshly dressed... | 40 | 16.4 | 200 | 2,748 | 310 | 390 | ...... | ...... | ...... | 27.51 | 5⅝ | 27.47 | ...... | ...... | ...... | ...... | 113.6 | .00687 |
| W-18[1]..... | 112 | .....do.......... | Same as for No. 111.[5] | 40 | 16.4 | 200 | 2,748 | 326 | 392 | 4.320 | 75.5 | 380 | 27.00 | 5⅝ | 29.84 | 2,270 | 84.3 | 8.41 | ...... | 141.8 | .00723 |
| W-18[2]..... | 114 | .....do.......... | Same as for No. 113.[5] | 40 | 16.4 | 200 | 2,748 | 342 | 388 | 4.625 | 73.9 | 405 | 27.19 | 6 | 39.66 | 2,282 | 84.1 | 7.96 | ...... | 110.9 | .00758 |
| W-18[2]..... | [6] 120 | .....do.......... | Same as for No. 119.[5] | 120 | 49.2 | 225 | 3,092 | 307 | 370 | 5.260 | 58.3 | 513 | 25.05 | 5⅞ | 40.34 | 2,055 | 82.0 | 13.42 | 158.4 | 124.5 | .00202 |
| W-18[2]..... | [4] 121 | .....do.......... | Same, not redressed. | 59.5 | 24.4 | 225 | 3,092 | 347 | 392 | 5.280 | 65.7 | 496 | 25.05 | 6 | 40.34 | 2,130 | 85.0 | 8.44 | ...... | 128.1 | .00460 |
| W-18[2]..... | 122 | .....do.......... | .....do.......... | 36.5 | 14.98 | 225 | 3,092 | 335 | 411 | 3.770 | 88.9 | 360 | 25.05 | 6 | 40.34 | 2,093 | 83.5 | 5.22 | 305.0 | 149.5 | .00724 |
| W-18[2]..... | 123 | .....do.......... | .....do.......... | 60 | 24.65 | 225 | 3,092 | 493 | 556 | 5.665 | 87.0 | 629 | 24.84 | 6¼ | 43.02 | 1,805 | 72.6 | 6.95 | ...... | 133.7 | .00646 |
| W-18[2]..... | 124 | .....do.......... | Freshly dressed... | 60 | 24.65 | 225 | 3,085 | 595 | 665 | 7.485 | 79.5 | 790 | 24.84 | 6½ | 43.02 | 1,898 | 76.3 | 10.40 | ...... | 137.8 | .00781 |
| W-18[2]..... | 125 | .....do.......... | Same, not dressed. | 40 | 16.4 | 225 | 3,085 | 419 | 475 | 4.390 | 95.5 | 426 | 24.84 | 6 | 43.02 | 2,058 | 82.7 | 6.79 | 134.0 | 141.3 | .00826 |
| W-18[2]..... | 126 | .....do.......... | .....do.......... | 20 | 8.2 | 225 | 3,085 | 232 | 290 | 1.703 | 136.2 | 176 | 24.84 | 6¾ | 43.02 | 1,928 | 77.5 | 5.37 | ...... | 163.8 | .00916 |
| W-20[1]..... | 127 | .....do.......... | .....do.......... | 60 | 24.65 | 225 | 3,085 | 567 | 629 | 6.950 | 81.6 | 577 | 28.01 | 5⅝ | 29.09 | 2,405 | 85.9 | 15.90 | ...... | 145.0 | .00745 |
| W-20[1]..... | 128 | .....do.......... | .....do.......... | 40 | 16.4 | 225 | 3,085 | 417 | 469 | 4.490 | 93.0 | 374 | 28.01 | 5 | 29.09 | 2,402 | 85.8 | 13.53 | ...... | 153.8 | .00825 |
| W-20[1]..... | 129 | .....do.......... | .....do.......... | 20 | 8.2 | 225 | 3,085 | 231 | 264 | 1.517 | 152.2 | 129 | 28.01 | 5¼ | 29.09 | 2,350 | 83.9 | 11.89 | ...... | 167.0 | .00913 |
| W-20[1]..... | 133 | .....do.......... | Same as for No. 132.[5] | 40 | 16.4 | 225 | 3,085 | 413 | 496 | 4.750 | 87.0 | 402 | 27.66 | 4⅝ | 28.08 | 2,360 | 85.4 | 8.39 | ...... | 133.2 | .00816 |
| W-20[1]..... | 134 | .....do.......... | Same, not redressed. | 40 | 16.4 | 225 | 3,085 | 411 | 478 | 4.210 | 97.8 | 353 | 27.66 | 5 | 28.08 | 2,380 | 86.0 | 13.34 | ...... | 172.0 | .00813 |
| W-20[1]..... | [4] 135 | .....do.......... | .....do.......... | 60 | 24.65 | 225 | 3,085 | 403 | 470 | 5.765 | 69.9 | 469 | 27.96 | 4⅝ | 26.41 | 2,460 | 88.0 | 10.70 | ...... | 121.4 | .00530 |
| W-20[1]..... | [4] 136 | .....do.......... | .....do.......... | 60 | 24.65 | 225 | 3,085 | 416 | 472 | 5.785 | 72.0 | 475 | 27.96 | 5⅛ | 26.41 | 2,435 | 87.0 | 13.75 | 116.0 | 173.0 | .00547 |

[1] Seasoned.
[2] Green.
[3] The low values of yield secured in runs Nos. 74 to 124 are the result of operating with a sulphite felt on the wet machine.
[4] Wood was ground in two pockets at a time.
[5] See Table 4.
[6] Wood was ground in one pocket at a time.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated*—Continued.

| Wood shipment No. | Run number. | Kind of burr. | Surface of stone. | Pressure on 14-inch cylinder. | Pressure per square inch of pocket area. | Revolutions per minute. | Peripheral speed. | Average horsepower to grinder. | Maximum horsepower to grinder. | Bone-dry pulp in 24 hours. | Horsepower per ton bone-dry pulp in 24 hours. | Solid rossed wood ground in 24 hours. | Weight per cubic foot bone-dry wood. | Average diameter of wood. | Moisture in wood. | Bone-dry pulp per 100 cubic feet solid rossed wood. | Efficiency of conversion. | Screenings per 100 cubic feet solid rossed wood bone-dry. | Stock in white water per 100 cubic feet solid rossed wood bone-dry. | Average temperature of grinding. | Horsepower ÷ pressure × speed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Lbs. per sq. in.* | *Lbs.* | | *Ft. per min.* | | | *Tons.* | | *Cu. ft.* | *Lbs.* | *In.* | *P. ct.* | *Lbs.* | *P. ct.* | *Lbs.* | *Lbs.* | *° F.* | |
| W-20[1] | 137 | Straight cut, 3 to inch; spiral cut, 12 to inch. | Same, not redressed. | 20 | 8.2 | 175 | 2,400 | 188 | 215 | 1.465 | 128.3 | 119.6 | 28.04 | 5½ | 27.75 | 2,450 | 87.4 | 10.30 | ...... | 148.3 | 0.00955 |
| W-20[1] | 138 | do | do | 40 | 16.4 | 175 | 2,400 | 338 | 384 | 3.435 | 98.5 | 278 | 28.04 | 5½ | 27.75 | 2,470 | 88.0 | 9.45 | 182.0 | 150.1 | .00859 |
| W-20[1] | 139 | do | do | 60 | 24.65 | 175 | 2,400 | 462 | 515 | 5.805 | 79.6 | 466 | 28.04 | 5¼ | 27.75 | 2,490 | 88.7 | 10.97 | 113.0 | 140.0 | .00780 |
| W-20[1] | 140 | do | do | 20 | 8.2 | 175 | 2,400 | 180 | 225 | 1.419 | 127.0 | 115.8 | 28.04 | 5½ | 27.75 | 2,450 | 87.4 | 10.70 | 157.0 | 159.3 | .00915 |
| W-20[1] | 141 | do | do | 40 | 16.4 | 175 | 2,400 | 323 | 346 | 3.495 | 92.5 | 282 | 28.04 | 6 | 27.75 | 2,480 | 88.4 | 12.11 | 125.0 | 152.9 | .00821 |
| W-20[1] | 142 | do | do | 60 | 24.65 | 175 | 2,400 | 465 | 515 | 5.775 | 80.5 | 475 | 28.04 | 5⅜ | 27.75 | 2,435 | 86.7 | 14.51 | 116.0 | 146.5 | .00785 |
| W-20[1] | 143 | do | do | 60 | 24.65 | 225 | 3,085 | 572 | 655 | 6.875 | 83.3 | 591 | 26.97 | 5½ | 27.05 | 2,325 | 86.4 | 14.49 | ...... | 150.0 | .00751 |
| W-20[1] | 144 | do | do | 60 | 24.65 | 225 | 3,085 | 555 | 634 | 6.585 | 84.4 | 564 | 26.97 | 5¼ | 27.05 | 2,335 | 86.6 | 14.83 | ...... | 157.8 | .00729 |
| W-20[1] | 145 | do | do | 60 | 24.65 | 225 | 3,085 | 586 | 665 | 7.405 | 79.1 | 625 | 26.97 | 5⅝ | 27.05 | 2,370 | 88.0 | 14.81 | ...... | 162.8 | .00770 |
| W-20[1] | 146 | do | do | 50 | 20.5 | 100 | 1,371 | 247.5 | 283 | 2.570 | 96.2 | 217.5 | 27.19 | 5⅝ | 26.12 | 2,360 | 86.9 | 15.89 | 208.0 | 154.0 | .00880 |
| W-20[1] | [2] 147 | do | do | 50 | 20.5 | 150 | 2,056 | 254 | 295 | 2.880 | 88.2 | 245 | 27.19 | 5 | 26.12 | 2,350 | 86.5 | 13.73 | 113.0 | 154.9 | .00603 |
| W-20[1] | [3] 148 | do | Same as for No. 147. | 50 | 20.5 | 250 | 3,427 | 222 | 254 | 2.590 | 85.7 | 218.3 | 27.19 | 6 | 26.12 | 2,370 | 87.1 | 12.38 | ...... | 147.1 | .00316 |
| W-20[1] | 149 | do | Same, not redressed. | 50 | 20.5 | 100 | 1,371 | 266 | 294 | 2.617 | 101.7 | 224 | 27.19 | 4⅝ | 26.12 | 2,340 | 86.1 | 18.53 | ...... | 162.0 | .00945 |
| W-20[1] | [2] 150 | do | do | 50 | 20.5 | 150 | 2,056 | 263 | 284 | 2.685 | 97.9 | 227.8 | 27.19 | 6⅜ | 26.12 | 2,360 | 86.9 | 9.69 | 133.0 | 161.0 | .00624 |
| W-20[1] | [3] 151 | do | do | 50 | 20.5 | 250 | 3,427 | 226 | 265 | 2.405 | 94.0 | 206 | 27.19 | 5 | 26.12 | 2,335 | 85.9 | 11.63 | ...... | 155.0 | .00322 |
| W-9[1] | 152 | do | do | 30 | 12.3 | 225 | 3,085 | 324 | 362 | 1.890 | 171.3 | 190.6 | 24.13 | 9⅝ | 32.00 | 1,983 | 82.3 | 11.30 | ...... | 181.9 | .00853 |
| W-20[1] | 153 | do | do | 30 | 12.3 | 225 | 3,085 | 298 | 340 | 1.233 | 241.8 | 116.3 | 26.91 | 5 | 22.93 | 2,120 | 78.9 | 17.57 | ...... | 186.0 | .00785 |
| W-20[1] | [2] 154 | do | do | 100 | 41.0 | 225 | 3,085 | 652 | 706 | 6.490 | 100.6 | 637 | 26.91 | 5 | 22.93 | 2,035 | 75.6 | 25.78 | ...... | 152.0 | .00515 |
| W-20[1] | 155 | Straight cut, 3 to inch; spiral cut, 10 to inch. | (4) | 40 | 16.4 | 225 | 3,085 | 444 | 489 | 2.205 | 200.6 | 194.6 | 28.20 | 5 | 22.10 | 2,270 | 80.5 | 5.05 | ...... | 86.5 | .00876 |
| W-20[1] | 156 | do | Same, not redressed. | 40 | 16.4 | 225 | 3,085 | 382 | 446 | 1.825 | 209.4 | 163 | 28.20 | 4⅞ | 22.10 | 2,240 | 79.5 | 12.31 | ...... | 187.2 | .00754 |
| W-20[1] | [2] 157 | do | do | 80 | 32.8 | 225 | 3,085 | 511 | 571 | 3.850 | 133 | 339 | 28.20 | 5 | 22.10 | 2,270 | 80.5 | 9.39 | ...... | 86.0 | .00505 |
| W-20[1] | [2] 158 | do | do | 80 | 32.8 | 225 | 3,085 | 474 | 509 | 4.160 | 113.9 | 363 | 28.20 | 5½ | 22.10 | 2,290 | 81.2 | 20.70 | ...... | 169.0 | .00468 |

[1] Seasoned.
[2] Wood was ground in two pockets at a time.
[3] Wood was ground in one pocket at a time.
[4] Approximately 1 ton of pulp was made on this surface before conducting test.

TABLE 4.—*Grinder runs on green and seasoned spruce, steamed prior to grinding.*

| Wood shipment number. | Run number. | Steaming treatment. Duration of cook. | Steaming treatment. Gauge pressure. | Surface of stone. | Pressure on 14-inch cylinder. | Pressure per square inch, pocket area. | Revolutions per minute. | Peripheral speed. | Average horsepower to grinder. | Maximum horsepower to grinder. | Bone-dry pulp in 24 hours. | Horsepower per ton bonedry pulp in 24 hours. | Solid wood ground in 24 hours. | Bone-dry weight per cubic foot, wood. | Dimensions of wood. Diameter. | Dimensions of wood. Length. | Per cent moisture in wood. | Bone-dry pulp per 100 cubic feet solid rossed wood. | Efficiency of conversion. | Weight of screenings per 100 cubic feet solid rossed wood. | Stock in white-water per 100 cubic feet solid rossed wood. | Average temperature of grinding. | Constant $\frac{HP.}{P \times S}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Hrs.* | *Lbs.* | | *Lbs.* | *Lbs.* | | *Ft. per min.* | | | *Tons.* | | *Cu. ft.* | *Lbs.* | *In.* | *Ft.* | | *Lbs.* | *P. ct.* | *Lbs.* | *Lbs.* | *°F.* | |
| W-91[1] | 51 | 8 | 60 | (2) | 40 | 16.4 | 200 | 2,762 | 326 | 372 | 3.130 | 104 | 340 | 22.96 | 9 1/8 | 1 | 39.08 | 1,840 | 80.2 | 18.47 | ........ | 156.6 | 0.00719 |
| W-171[1] | 57 | [3] 4 | 60 | Same as for No. 56[4] | 40 | 16.4 | 200 | 2,762 | 335 | 394 | 3.380 | 99.2 | 296 | 27.11 | 5 1/4 | 2 | 25.31 | 2,283 | 84.4 | 23.60 | ........ | 156 | .00739 |
| W-181[1] | 72 | 8 | 60 | (2) | 40 | 16.4 | 200 | 2,762 | 301 | 358 | 2.250 | 133.9 | 250 | 25.06 | 6 1/2 | 2 | 30.36 | 1,800 | 71.0 | 16.15 | ........ | 166.4 | .00664 |
| W-181[1] | 73 | 2 | 60 | (2) | 40 | 16.4 | 200 | 2,762 | 352.5 | 415 | 2.800 | 126 | 264 | 26.84 | 5 7/8 | 2 | 30.73 | 2,122 | 79.0 | 19.25 | ........ | 164.1 | .00777 |
| W-181[1] | 77 | 4 | 60 | Same, not redressed | 20 | 8.2 | 175 | 2,417 | 172.2 | 212 | .784 | 220 | 79.2 | 26.06 | 5 1/4 | 2 | 31.29 | 1,980 | 76.0 | 12.48 | ........ | 171 | .00871 |
| W-181[1] | 78 | 4 | 60 | .....do | 40 | 16.4 | 175 | 2,417 | 299 | 349 | 2.155 | 138.8 | 208.5 | 27.48 | 6 | 2 | 28.61 | 2,066 | 75.2 | 18.19 | ........ | 158.2 | .00755 |
| W-181[1] | 79 | 4 | 60 | .....do | 60 | 24.65 | 175 | 2,417 | 373 | 449 | 2.935 | 127.1 | 292 | 27.14 | 6 1/8 | 2 | 28.83 | 2,013 | 74.2 | 23.90 | ........ | 149.4 | .00626 |
| W-185[5] | [6] 97 | 6 | 60 | Freshly dressed | 20 | 8.2 | 225 | 3,092 | 153.2 | 189 | 1.803 | 84.9 | 197.8 | 26.66 | 6 5/8 | 2 | 36.51 | 1,823 | 68.4 | 10.08 | ........ | 131.5 | .00605 |
| W-185[5] | [6] 98 | 6 | 60 | Same, not redressed | 40 | 16.4 | 225 | 3,092 | 229.5 | 272 | 3.365 | 68.1 | 352 | 27.19 | 6 | 2 | 39.66 | 1,910 | 70.3 | 18.32 | ........ | 121.1 | .00452 |
| W-185[5] | [6] 99 | 6 | 60 | .....do | 60 | 24.65 | 225 | 3,092 | 308.2 | 360 | 4.020 | 76.7 | 426 | 27.19 | 7 | 2 | 39.66 | 1,883 | 69.4 | 27.37 | ........ | 120.2 | .00404 |
| W-185[5] | [6] 100 | 6 | 60 | .....do | 80 | 32.8 | 225 | 3,092 | 369 | 401 | 4.655 | 79.1 | 496 | 27.19 | 6 1/4 | 2 | 39.66 | 1,876 | 69.0 | 34.00 | 73.1 | 125.1 | .00364 |
| W-185[5] | [6] 101 | 6 | 60 | .....do | 100 | 41.0 | 225 | 3,092 | 420 | 510 | 4.615 | 90.9 | 487 | 27.19 | 6 1/8 | 2 | 39.66 | 1,896 | 69.7 | 45.85 | 159 | 128.4 | .00332 |
| W-185[5] | [7] 102 | 6 | 60 | Freshly dressed | 40 | 16.4 | 200 | 2,748 | 280 | 320 | 3.075 | 91.1 | 376 | 25.06 | 6 1/4 | 2 | 44.00 | 1,636 | 65.3 | 18.57 | 119 | 125 | .00621 |
| W-181[1] | 103 | 2 | 20 | Same, not redressed | 40 | 16.4 | 200 | 2,748 | 332 | 382 | 4.195 | 79.1 | 378 | 27.81 | 6 1/2 | 2 | 26.22 | 2,219 | 79.7 | 12.28 | 111 | 128.7 | .00736 |
| W-181[1] | 104 | 4 | 20 | .....do | 40 | 16.4 | 200 | 2,743 | 323 | 393 | 4.210 | 76.7 | 390 | 27.31 | 6 3/8 | 2 | 26.22 | 2,160 | 77.6 | 16.86 | 103 | 137 | .00716 |
| W-181[1] | 105 | 6 | 20 | .....do | 40 | 16.4 | 200 | 2,748 | 326.5 | 364 | 3.995 | 81.8 | 422 | 27.81 | 5 3/4 | 2 | 26.22 | 1,892 | 68.0 | 10.36 | 89.0 | 126.1 | .00725 |
| W-181[1] | 106 | 8 | 20 | .....do | 40 | 16.4 | 200 | 2,748 | 320 | 382 | 3.595 | 89.1 | 346 | 27.30 | 5 3/8 | 2 | 27.56 | 2,081 | 76.3 | 17.81 | ........ | 137.8 | .00710 |
| W-181[1] | 107 | 12 | 20 | .....do | 40 | 16.4 | 200 | 2,748 | 323 | 398 | 3.565 | 90.6 | 344 | 27.30 | 5 7/8 | 2 | 27.56 | 2,070 | 75.8 | 19.93 | 42.7 | 136.4 | .00716 |
| W-181[1] | 108 | 2 | 40 | .....do | 40 | 16.4 | 200 | 2,748 | 339 | 393 | 3.810 | 89 | 337 | 26.50 | 5 1/2 | 2 | 29.88 | 2,263 | 85.5 | 16.53 | ........ | 144.9 | .00752 |
| W-181[1] | 109 | 4 | 40 | .....do | 40 | 16.4 | 200 | 2,748 | 307 | 363 | 3.705 | 82.9 | 342 | 26.50 | 5 5/8 | 2 | 29.88 | 2,170 | 82.0 | 21.80 | 124 | 134.0 | .00681 |
| W-181[1] | 110 | 6 | 40 | .....do | 40 | 16.4 | 200 | 2,748 | 285 | 342 | 2.927 | 97.4 | 278 | 26.50 | 5 1/4 | 2 | 29.88 | 2,105 | 79.5 | 15.80 | 61.5 | 142.2 | .00632 |
| W-181[1] | 111 | 8 | 40 | .....do | 40 | 16.4 | 200 | 2,748 | 275 | 323 | 3.037 | 90.6 | 304 | 26.50 | 5 3/8 | 2 | 29.88 | 2,000 | 75.5 | 12.98 | ........ | 139.5 | .00610 |
| W-181[1] | 113 | 12 | 40 | Same as for 112[4] | 40 | 16.4 | 200 | 2,748 | 288 | 342 | 2.985 | 96.5 | 299 | 26.50 | 5 1/2 | 2 | 29.88 | 1,998 | 75.4 | 10.40 | ........ | 143.7 | .00639 |
| W-187[7] | 115 | 2 | 60 | Same as for 114[4] | 40 | 16.4 | 200 | 2,748 | 294 | 368 | 3.260 | 90.1 | 314 | 27.19 | 5 7/8 | 2 | 39.66 | 2,080 | 76.5 | 10.96 | ........ | 137.9 | .00652 |
| W-185[5] | 116 | 4 | 60 | Same, not redressed | 40 | 16.4 | 200 | 2,743 | 252 | 303 | 2.475 | 101.9 | 270 | 25.05 | 6 1/4 | 2 | 40.34 | 1,830 | 73.2 | 19.30 | ........ | 140.8 | .00550 |
| W-185[5] | 117 | 6 | 60 | .....do | 40 | 16.4 | 200 | 2,748 | 271 | 328 | 2.540 | 106.7 | 294.5 | 25.05 | 6 | 2 | 40.34 | 1,722 | 68.8 | 11.13 | ........ | 138.1 | .00601 |
| W-185[5] | 118 | 8 | 60 | .....do | 40 | 16.4 | 200 | 2,748 | 283 | 329 | 2.775 | 102 | 325 | 25.05 | 6 | 2 | 40.34 | 1,710 | 68.3 | 14.76 | 105 | 138.6 | .00627 |
| W-187[7] | 119 | 12 | 60 | .....do | 40 | 16.4 | 200 | 2,748 | 277 | 329 | 2.805 | 98.8 | 336 | 25.05 | 6 3/8 | 2 | 40.34 | 1,670 | 66.7 | 13.10 | 113 | 138.6 | .00614 |
| W-201[1] | 130 | 4 | 60 | Same as for No. 129[4] | 60 | 24.65 | 225 | 3,085 | 495 | 590 | 5.110 | 96.7 | 482 | 28.01 | 5 1/8 | 2 | 29.09 | 2,124 | 75.9 | 45.70 | 281 | 143.6 | .00650 |
| W-201[1] | 131 | 4 | 60 | Same, not redressed | 40 | 16.4 | 225 | 3,085 | 378 | 435 | 3.807 | 99.3 | 362 | 27.66 | 4 5/8 | 2 | 28.08 | 2,100 | 75.9 | 19.87 | 321 | 145.1 | .00746 |
| W-201[1] | 132 | 4 | 60 | .....do | 20 | 8.2 | 225 | 3,085 | 230 | 268 | 1.977 | 116.3 | 186.8 | 27.66 | 4 1/2 | 2 | 28.08 | 2,118 | 76.5 | 10.55 | ........ | 149.3 | .00908 |

[1] Seasoned.
[2] Approximately 1 ton of pulp was made on the stone before this test was run.
[3] Boiled in 0.3 per cent soda ash solution.
[4] See Table 3.
[5] Green.
[6] Wood was ground in but two pockets at a time.
[7] Not barked.

NOTE.—Kind of burr: Straight cut, 3 to the inch; and spiral cut, 12 to the inch. Kind of stone: Lombard.

TABLE 5.—*Quality tests of papers manufactured from experimental pulps.*

| Grinder run number. | Paper-machine run number. | Weight per ream. | Thickness. | Mullen test. Total. | Mullen test. Per 0.001 inch of thickness. | Mullen test. Per pound. | Mullen test. Horsepower per ton divided by strength factor. | Schopper tests. Breaking length. Crosswise. | Schopper tests. Breaking length. Lengthwise. | Schopper tests. Breaking length. Average. | Schopper tests. Stretch. Crosswise. | Schopper tests. Stretch. Lengthwise. | Schopper tests. Stretch. Average. | Schopper tests. Breaking weight per square millimeter, sectional area. | Schopper tests. Breaking length per horsepower per ton. | Tintometer indications. Red. | Tintometer indications. Green. | Tintometer indications. Blue. | Tintometer indications. Black. | Microscopic classification. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Inches.* | *Points.* | *Points.* | *Points.* | | *Meters.* | *Meters.* | *Meters.* | *Per ct.* | *Per ct.* | *Per ct.* | *Grams.* | *Meters.* | *Parts.* | *Parts.* | *Parts.* | *Parts.* | |
| 1 | | | | | | | | | | | | | | | | | | | | 1 |
| 2 | 110 | 32 | 0.00387 | 12.15 | 3.14 | 0.380 | 256 | 2,600 | 4,000 | 3,300 | 3.00 | 1.40 | 2.20 | 1,506 | 33.9 | 95 | 86 | 78 | 41 | 1 |
| 3 | 62 | 32 | .0036 | 16.4 | 4.55 | .513 | 306 | 3,075 | 5,300 | 4,188 | 2.04 | 1.22 | 1.63 | 2,050 | 26.7 | 89 | 80 | 73 | 58 | 1 |
| 4 | 75 | 37 | .0041 | 19.35 | 4.72 | .523 | 210 | 3,585 | 6,040 | 4,821 | 1.98 | 1.04 | 1.51 | 2,440 | 43.8 | 87 | 76 | 66 | 71 | 2 |
| 5 | 42 | 29 | .0038 | 11.3 | 2.97 | .390 | 221 | 2,420 | 4,640 | 3,530 | 1.74 | .98 | 1.36 | 1,462 | 40.8 | 89 | 78 | 68 | 65 | 2 |
| 6 | 11 | 40 | .0047 | 21.4 | 4.55 | .535 | 351 | 2,500 | 5,440 | 3,970 | 1.18 | 1.10 | 1.14 | 1,936 | 21.2 | 90 | 80 | 70 | 60 | 1 |
| 7 | 22 | 33 | .0038 | 15.7 | 4.13 | .476 | 229 | 3,120 | 6,210 | 4,665 | 1.76 | 1.06 | 1.41 | 2,130 | 42.8 | 88 | 79 | 69 | 64 | 2 |
| 8 | 56 | 34 | .0043 | 14.05 | 3.27 | .413 | 221 | 2,673 | 4,780 | 3,727 | 1.66 | 1.10 | 1.38 | 1,590 | 40.9 | 87 | 77 | 64 | 72 | 5 |
| 9 | 51 | 33 | .00384 | 17.95 | 4.72 | .544 | 323 | 3,344 | 5,690 | 4,517 | 2.86 | 1.58 | 2.22 | 2,350 | 25.7 | 82 | 71 | 61 | 86 | 2 |
| 9–1 | 16 | 35 | .0046 | 17.50 | 3.74 | .493 | 189 | 3,040 | 5,410 | 4,225 | 1.58 | .98 | 1.28 | 1,272 | 45.2 | 96 | 79 | 75 | 50 | 1 |
| 10 | 72 | 33 | .00394 | 14.15 | 3.60 | .429 | 174 | 2,973 | 5,358 | 4,166 | 1.40 | 1.04 | 1.22 | 1,975 | 55.9 | 81 | 73 | 66 | 80 | 4 |
| 11 | 45 | 34 | .0042 | 12.35 | 2.94 | .363 | 180 | 2,123 | 4,335 | 3,229 | 2.92 | 1.30 | 2.11 | 1,360 | 49.3 | 91 | 78 | 70 | 61 | 4 |
| 12 | 92 | 34 | .00417 | 15.65 | 3.75 | .460 | 163 | 3,180 | 5,320 | 4,250 | 1.78 | 1.22 | 1.50 | 1,895 | 56.6 | 97 | 85 | 76 | 42 | 2 |
| 13 | 20 | 34 | .0040 | 13.00 | 3.25 | .382 | 176 | 2,655 | 5,030 | 3,843 | 1.98 | 1.10 | 1.54 | 1,680 | 57.3 | 90 | 79 | 66 | 65 | 2 |
| 14 | 28 | 34 | .0047 | 13.00 | 2.77 | .382 | 170 | 2,065 | 4,325 | 3,195 | 1.94 | 1.12 | 1.53 | 1,330 | 49.2 | 90 | 79 | 69 | 62 | 4 |
| 14 | 29 | 32 | .00414 | 11.45 | 2.77 | .358 | 181 | 2,228 | 4,020 | 3,124 | 1.74 | 1.02 | 1.38 | 1,240 | 48.2 | 90 | 80 | 74 | 56 | 4 |
| 15 | 61 | 30 | .00343 | 16.55 | 4.83 | .552 | 231 | 3,865 | 5,750 | 4,808 | 2.22 | 1.10 | 1.66 | 2,340 | 37.7 | 84 | 72 | 66 | 78 | 4 |
| 16 | 19 | 38 | .0043 | 17.45 | 4.06 | .459 | 192 | 3,098 | 5,960 | 4,529 | 2.16 | 1.26 | 1.71 | 2,114 | 51.3 | 85 | 75 | 64 | 76 | 5 |
| 17 | 48 | 33 | .00298 | 13.40 | 4.47 | .406 | 196 | 2,395 | 3,795 | 3,095 | 2.40 | .98 | 1.64 | 1,940 | 38.8 | 88 | 73 | 65 | 74 | 2 |
| 18 | 73 | 29 | .0033 | 14.50 | 4.40 | .500 | 224 | 3,085 | 5,850 | 4,468 | 1.76 | 1.16 | 1.46 | 2,119 | 39.9 | 86 | 77 | 70 | 67 | 2 |
| 19 | 91 | 35 | .00397 | 16.35 | 4.12 | .467 | 192 | 3,350 | 5,360 | 4,355 | 2.00 | 1.20 | 1.60 | 2,085 | 48.5 | 95 | 82 | 75 | 48 | 4 |
| 20 | 43 | 31 | .0039 | 13.90 | 3.56 | .448 | 183 | 2,865 | 4,855 | 3,860 | 1.94 | 1.00 | 1.47 | 1,613 | 47.1 | 92 | 82 | 71 | 55 | 4 |
| 21 | 21 | 44 | .0045 | 25.6 | 5.69 | .582 | 249 | 3,384 | 6,680 | 5,032 | 2.56 | 1.48 | 2.02 | 2,700 | 34.8 | 87 | 78 | 67 | 68 | 4 |
| 22 | 77 | 33 | .00354 | 17.15 | 4.85 | .520 | 273 | 3,400 | 5,850 | 4,625 | 2.02 | 1.24 | 1.63 | 2,350 | 32.6 | 82 | 69 | 61 | 88 | 2 |
| 23 | 79 | 33 | .00355 | 18.7 | 5.27 | .567 | 236 | 3,570 | 5,910 | 4,740 | 2.46 | 1.24 | 1.85 | 2,420 | 35.3 | 84 | 75 | 70 | 71 | 2 |
| 24 | 67 | 33 | .0037 | 16.75 | 4.63 | .508 | 196 | 3,165 | 5,430 | 4,298 | 2.22 | 1.32 | 1.77 | 2,010 | 43.1 | 86 | 74 | 67 | 73 | 5 |
| 25 | 59 | 31 | .00373 | 15.9 | 4.30 | .513 | 174 | 3,045 | 4,840 | 3,943 | 2.18 | 1.18 | 1.68 | 1,850 | 44.1 | 78 | 66 | 58 | 98 | 5 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 50 | 36 | .0041 | 17.9 | 4.36 | .497 | 178 | 3,000 | 5,650 | 4,325 | 2.60 | 1.60 | 2.10 | 2,150 | 48.7 | 88 | 75 | 64 | 73 | 5 |
| 27 | 8 | 33 | .0042 | 13.85 | 3.30 | .420 | 194 | 2,445 | 5,018 | 3,732 | 1.24 | 1.05 | 1.15 | 1,656 | 45.8 | 85 | 71 | 66 | 78 | 5 |
| 28 | 95 | 35 | .0039 | 18.2 | 4.67 | .520 | 229 | 2,965 | 5,200 | 3,833 | 2.00 | 1.08 | 1.54 | 2,185 | 32.1 | 95 | 79 | 71 | 55 | 5 |
| 29 | 96 | 32 | .00365 | 16.1 | 4.41 | .503 | 240 | 3,570 | 5,480 | 4,525 | 2.04 | 1.12 | 1.58 | 2,170 | 37.6 | 88 | 79 | 71 | 62 | 5 |
| 29-1 | 64 | 31 | .0036 | 15.15 | 4.21 | .489 | 261 | 3,195 | 5,020 | 4,108 | 2.22 | 1.14 | 1.68 | 1,975 | 32.2 | 85 | 76 | 68 | 71 | 2 |
| 30 | 58 | 31 | .00364 | 15.00 | 4.17 | .484 | 191 | 3,295 | 5,400 | 4,348 | 2.12 | 1.14 | 1.63 | 1,914 | 47.0 | 87 | 78 | 67 | 68 | 2 |
| 31 | 26 | 31 | .0035 | 13.25 | 3.79 | .427 | 234 | 3,050 | 5,480 | 4,255 | 1.72 | 1.08 | 1.40 | 1,928 | 42.5 | 91 | 80 | 72 | 57 | 2 |
| 32 | 66 | 31 | .0041 | 8.5 | 2.07 | .274 | 220 | 2,085 | 3,745 | 2,915 | 1.12 | .94 | 1.03 | 1,220 | 48.2 | 87 | 78 | 71 | 64 | 3 |
| 33 | 24 | 33 | .0045 | 10.0 | 2.22 | .303 | 188 | 2,180 | 4,230 | 3,205 | 1.36 | .88 | 1.12 | 1,254 | 56.2 | 87 | 77 | 69 | 67 | 3 |
| 34 | 17 | 33 | .0047 | 10.75 | 2.29 | .326 | 186 | 2,140 | 4,000 | 3,070 | 1.20 | .88 | 1.04 | 1,260 | 50.6 | 90 | 76 | 66 | 68 | 3 |
| 35 | 23 | 33 | .0044 | 11.7 | 2.66 | .354 | 183.5 | 2,282 | 4,600 | 3,441 | 1.48 | .96 | 1.22 | 1,365 | 53.1 | 83 | 72 | 61 | 84 | 4 |
| 36 | 18 | 32 | .0041 | 11.45 | 2.73 | .358 | 181 | 2,294 | 4,935 | 3,615 | 1.48 | 1.00 | 1.24 | 1,500 | 55.8 | 90 | 79 | 70 | 61 | 4 |
| 37 | 53 | 34 | .0043 | 12.35 | 2.87 | .363 | 174 | 2,700 | 4,060 | 3,380 | 2.04 | 1.12 | 1.58 | 1,414 | 53.5 | 86 | 74 | 66 | 74 | 4 |
| 37 | 55 | 34 | .00436 | 12.35 | 2.83 | .363 | 174 | 2,560 | 3,970 | 3,265 | 1.96 | 1.08 | 1.52 | 1,340 | 51.7 | 88 | 76 | 64 | 72 | 4 |
| 38 | 54 | 34 | .0044 | 11.60 | 2.64 | .341 | 197 | 2,330 | 3,570 | 2,950 | 1.78 | 1.08 | 1.43 | 1,236 | 44.0 | 83 | 70 | 61 | 86 | 4 |
| 39 | 69 | 30 | .00363 | 9.95 | 2.74 | .331 | 221 | 2,500 | 4,725 | 3,613 | 1.04 | .98 | 1.01 | 1,570 | 49.5 | 81 | 70 | 62 | 87 | 5 |
| 40 | 14 | 33 | .0044 | 13.80 | 3.14 | .330 | 232 | 2,750 | 4,635 | 3,693 | 1.44 | .98 | 1.21 | 1,615 | 48.2 | 89 | 74 | 65 | 72 | 4 |
| 41 | 74 | 30 | .0039 | 12.10 | 3.10 | .403 | 181 | 2,805 | 4,950 | 3,878 | 1.46 | 1.08 | 1.27 | 1,610 | 53.1 | 84 | 71 | 63 | 82 | 2 |
| 42 | 39 | 31 | .0035 | 13.70 | 3.91 | .442 | 229 | 2,773 | 5,280 | 4,026 | 2.14 | 1.12 | 1.63 | 2,014 | 39.8 | 87 | 76 | 72 | 65 | 5 |
| 43 | 47 | 32 | .0037 | 13.8 | 3.73 | .431 | 235 | 2,810 | 5,210 | 4,010 | 2.14 | 1.32 | 1.73 | 1,910 | 39.6 | 88 | 80 | 70 | 62 | |
| 44 | 25 | 31 | .0036 | 11.9 | 3.30 | .384 | 224 | 2,650 | 5,170 | 3,910 | 1.40 | 1.00 | 1.20 | 1,695 | 45.5 | 84 | 72 | 61 | 83 | |
| 45 | 52 | 35 | .0037 | 15.95 | 4.31 | .455 | 353 | 3,055 | 4,950 | 4,003 | 2.72 | 1.36 | 2.04 | 2,010 | 25.0 | 79 | 69 | 59 | 93 | |
| 46 | 40 | 30 | .0038 | 14.45 | 3.80 | .482 | 197 | 5,280 | 5,135 | 3,858 | 2.54 | 1.22 | 1.88 | 1,710 | 40.7 | 87 | 79 | 70 | 64 | |
| 47 | 44 | 32 | .0040 | 13.6 | 3.40 | .425 | 188 | 2,714 | 4,620 | 3,517 | 2.54 | 1.54 | 2.04 | 1,545 | 44.0 | 87 | 75 | 66 | 72 | |
| 48 | 60 | 32 | .0036 | 14.6 | 4.05 | .456 | 288 | 3,455 | 5,415 | 4,435 | 2.02 | 1.00 | 1.51 | 2,200 | 33.8 | 80 | 70 | 61 | 89 | |
| 49 | 49 | 32 | .00356 | 14.8 | 4.11 | .462 | 246 | 3,014 | 5,280 | 4,147 | 2.14 | 1.28 | 1.71 | 1,940 | 36.5 | 84 | 73 | 68 | 75 | |
| 50 | 41 | 33 | .0040 | 14.7 | 3.68 | .444 | 210 | 2,890 | 5,300 | 4,095 | 1.72 | 1.06 | 1.39 | 1,840 | 44.0 | 86 | 79 | 69 | 66 | |
| 51 | 85 | 36 | .0037 | 20.5 | 5.55 | .569 | 183 | 3,460 | 5,400 | 4,430 | 2.68 | 1.16 | 1.92 | 2,355 | 42.6 | 58 | 40 | 36 | 166 | 1 |
| 52 | 97 | 35 | .00295 | 17.35 | 5.88 | .495 | 366 | 3,525 | 4,805 | 4,165 | 1.92 | .84 | 1.38 | 2,880 | 23.0 | 83 | 76 | 68 | 73 | 2 |
| 53 | 63 | 29 | .00336 | 11.25 | 3.35 | .388 | 270 | 2,925 | 5,155 | 4,040 | 1.84 | 1.14 | 1.49 | 1,810 | 38.6 | 89 | 79 | 69 | 63 | 2 |
| 54 | 62 | 35 | .00423 | 13.30 | 3.14 | .380 | 180 | 2,985 | 4,580 | 3,783 | 1.84 | 1.16 | 1.50 | 1,728 | 55.5 | 83 | 73 | 69 | 75 | 4 |
| 55 | 68 | 29 | .0039 | 8.9 | 2.28 | .306 | 195 | 2,445 | 4,260 | 3,353 | 1.50 | 1.02 | 1.26 | 1,395 | 56.2 | 88 | 78 | 71 | 63 | 4 |
| 56 | 71 | 31 | .0048 | 10.5 | 2.48 | .326 | 175 | 2,300 | 4,060 | 3,180 | 1.18 | .92 | 1.05 | 1,394 | 55.8 | 86 | 74 | 66 | 74 | 4 |
| 57 | 80 | 35 | .0041 | 16.45 | 4.01 | .470 | 211 | 3,245 | 5,350 | 4,298 | 2.26 | 1.18 | 1.72 | 1,934 | 43.3 | 82 | 68 | 63 | 87 | 1 |
| 58 | 83 | 32 | .00417 | 11.45 | 2.74 | .358 | 173 | 2,715 | 4,385 | 3,550 | 1.44 | 1.00 | 1.22 | 1,517 | 57.2 | 87 | 75 | 68 | 70 | 3 |
| 59 | | | | | | | | | | | | | | | | | | | | |
| 60 | 86 | 30 | .0036 | 13.85 | 3.85 | .461 | 199.5 | 3,110 | 5,190 | 4,150 | 1.82 | 1.20 | 1.51 | 2,000 | 45.1 | 91 | 81 | 72 | 56 | 5 |
| 61 | 87 | 33 | .00375 | 15.95 | 4.25 | .483 | 189 | 3,110 | 5,000 | 4,055 | 2.20 | 1.36 | 1.78 | 1,953 | 44.3 | 91 | 79 | 74 | 56 | 4 |
| 62 | 81 | 34 | .00416 | 14.05 | 3.38 | .413 | 210 | 3,040 | 4,865 | 3,953 | 2.04 | 1.18 | 1.61 | 1,775 | 45.5 | 91 | 78 | 69 | 62 | 4 |
| 63 | 78 | 32 | .0040 | 12.15 | 3.04 | .380 | 215 | 2,910 | 5,040 | 3,975 | 1.52 | 1.10 | 1.31 | 1,712 | 48.6 | 85 | 76 | 67 | 72 | 4 |
| 64 | 76 | 29 | .00365 | 11.95 | 3.28 | .412 | 191 | 2,760 | 4,635 | 3,697 | 1.60 | 1.02 | 1.31 | 1,640 | 47.0 | 88 | 76 | 67 | 69 | 5 |
| 65 | 6 | 33 | .0040 | 11.40 | 2.85 | .345 | 233 | 2,445 | 4,829 | 3,637 | 1.63 | 1.01 | 1.32 | 1,569 | 45.1 | 87 | 75 | 66 | 72 | 4 |
| 66 | 57 | 33 | .00425 | 14.05 | 3.31 | .426 | 194.5 | 2,910 | 4,635 | 3,773 | 2.00 | 1.10 | 1.55 | 1,640 | 45.5 | 84 | 72 | 62 | 82 | 4 |

TABLE 5.—*Quality tests of papers manufactured from experimental pulps*—Continued.

| Grinder run number. | Paper-machine run number. | Weight per ream. | Thickness. | Mullen test. | | | | Schopper tests. | | | | | | | | Tintometer indications. | | | | Microscopic classification. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total. | Per 0.001 inch of thickness. | Per pound. | Horsepower per ton divided by strength factor. | Breaking length. Crosswise. | Breaking length. Lengthwise. | Breaking length. Average. | Stretch. Crosswise. | Stretch. Lengthwise. | Stretch. Average. | Breaking weight per square millimeter, sectional area. | Breaking length per horsepower per ton. | Red. | Green. | Blue. | Black. | |
| | | *Pounds.* | *Inches.* | *Points.* | *Points.* | *Points.* | | *Meters.* | *Meters.* | *Meters.* | *Per ct.* | *Per ct.* | *Per ct.* | *Grams.* | *Meters.* | *Parts.* | *Parts.* | *Parts.* | *Parts.* | |
| 67 | 4 | 35 | 0.0052 | 12.35 | 2.38 | 0.353 | 211 | 2,155 | 4,218 | 3,187 | 1.35 | 1.02 | 1.19 | 1,395 | 42.8 | 86 | 76 | 66 | 73 | 3 |
| 68 | 13 | 34 | .0047 | 14.75 | 3.14 | .434 | 188.5 | 2,750 | 4,840 | 3,795 | 1.72 | 1.06 | 1.39 | 1,610 | 46.4 | 89 | 79 | 70 | 62 | 4 |
| 69 | 12 | 32 | .0043 | 12.8 | 2.98 | .400 | 171.5 | 2,485 | 4,450 | 3,467 | 1.58 | .96 | 1.27 | 1,510 | 48.3 | 92 | 83 | 73 | 52 | 4 |
| 70 | 3 | 32 | .0042 | 9.2 | 2.18 | .288 | 219 | 2,053 | 4,095 | 3,074 | 1.26 | .95 | 1.11 | 1,203 | 48.8 | 84 | 70 | 62 | 84 | 4 |
| 71 | 10 | 34 | .0046 | 11.15 | 2.42 | .328 | 185.5 | 2,045 | 4,150 | 3,088 | 1.64 | .98 | 1.31 | 1,310 | 50.8 | 84 | 76 | 74 | 66 | 4 |
| 72 | 166 | 37 | .00354 | 18.30 | 5.169 | .4946 | 271 | 3,050 | 5,206 | 4,128 | 2.08 | 1.18 | 1.63 | 2,368 | 30.8 | 46 | 31 | 24 | 199 | ........ |
| 73 | 170 | 33 | .00458 | 19.00 | 4.150 | .576 | 218 | 3,000 | 4,780 | 3,890 | 2.42 | 1.26 | 1.84 | 1,940 | 30.9 | 57 | 45 | 39 | 159 | ........ |
| 74 | 175 | 32 | .00369 | 10.15 | 2.750 | .3170 | 283 | 1,985 | 3,705 | 2,845 | 2.00 | 1.10 | 1.55 | 1,421 | 31.7 | 68 | 61 | 54 | 117 | ........ |
| 75 | 176 | 34 | .00374 | 15.00 | 4.01 | .4415 | 258 | 2,898 | 4,852 | 3,875 | 2.30 | 1.30 | 1.80 | 1,982 | 34.1 | 68 | 66 | 56 | 115 | ........ |
| 76 | 177 | 34 | .00357 | 17.25 | 4.83 | .5075 | 371 | 2,965 | 5,635 | 4,300 | 2.14 | 1.36 | 1.75 | 2,235 | 22.8 | 67 | 58 | 55 | 120 | ........ |
| 77 | 171 | 35 | .00348 | 17.50 | 5.030 | .500 | 440 | 3,100 | 5,430 | 4,265 | 2.56 | 1.54 | 2.05 | 3,240 | 19.4 | 45 | 32 | 27 | 196 | ........ |
| 78 | 167 | 36 | .00372 | 19.90 | 5.350 | .5532 | 251 | 3,408 | 5,424 | 4,416 | 2.34 | 1.20 | 1.77 | 2,425 | 31.8 | 63 | 44 | 38 | 155 | ........ |
| 79 | 192 | 33 | .00349 | 17.70 | 5.070 | .5364 | 237 | 3,520 | 6,744 | 5,132 | 1.84 | 1.08 | 1.46 | 2,801 | 40.3 | 53 | 34 | 27 | 186 | ........ |
| 80 | 190 | 31 | .00326 | 15.85 | 4.86 | .5112 | 559 | 3,688 | 7,460 | 5,574 | 1.80 | 1.18 | 1.49 | 3,002 | 19.5 | 76 | 70 | 64 | 90 | ........ |
| 81 | 191 | 31 | .00351 | 13.90 | 3.96 | .4484 | 295 | 3,459 | 6,631 | 5,045 | 1.94 | 1.06 | 1.50 | 2,439 | 38.1 | 97 | 85 | 70 | 48 | ........ |
| 82 | 172 | 35 | .00408 | 14.00 | 3.43 | .405 | 242 | 2,475 | 4,100 | 3,288 | 2.34 | 1.32 | 1.83 | 1,580 | 33.6 | 67 | 55 | 48 | 130 | ........ |
| 83 | 184 | 31 | .00367 | 11.70 | 3.19 | .3775 | 261 | 2,995 | 5,100 | 4,047 | 1.72 | 1.04 | 1.38 | 1,891 | 41.0 | 75 | 67 | 61 | 97 | ........ |
| 84 | 183 | 34 | .00414 | 15.54 | 3.73 | .4545 | 258 | 2,840 | 5,270 | 4,055 | 1.74 | 1.10 | 1.42 | 1,893 | 34.6 | 78 | 65 | 62 | 95 | ........ |
| 85 | 169 | 35 | .00899 | 14.20 | 3.312 | .4060 | 228 | 3,176 | 4,826 | 4,001 | 1.90 | 1.04 | 1.47 | 1,958 | 43.1 | 87 | 76 | 69 | 68 | ........ |
| 86 | 178 | 34 | .40042 | 14.10 | 3.37 | .4100 | 216 | 2,890 | 4,850 | 3,870 | 1.72 | .98 | 1.35 | 1,725 | 43.7 | 75 | 65 | 60 | 100 | ........ |
| 87 | 179 | 34 | .00399 | 15.50 | 3.89 | .4565 | 265 | 3,095 | 5,685 | 4,390 | 1.78 | 1.16 | 1.43 | 2,140 | 36.2 | 86 | 78 | 71 | 65 | ........ |
| 88 | 163 | 30 | .00367 | 11.80 | 3.217 | .3935 | 290 | 2,830 | 4,688 | 3,759 | 2.06 | 1.22 | 1.64 | 1,748 | 32.9 | 84 | 74 | 71 | 71 | ........ |
| | 180 | 35 | .00400 | 14.25 | 3.56 | .4070 | 281 | 2,883 | 4,610 | 3,746 | 1.82 | 1.18 | 1.50 | 1,803 | 32.8 | 92 | 81 | 73 | 54 | ........ |
| 89 | 181 | 32 | .00394 | 10.65 | 2.70 | .3200 | 268 | 2,578 | 4,460 | 3,519 | 1.44 | .92 | 1.18 | 1,637 | 41.0 | 85 | 72 | 68 | 75 | ........ |
| 90 | 182 | 32 | .00417 | 11.25 | 2.70 | .3517 | 224 | 2,700 | 4,228 | 3,464 | 1.54 | .82 | 1.18 | 1,508 | 44.1 | 87 | 78 | 69 | 66 | ........ |
| 91 | 198 | 30 | .00361 | 12.35 | 3.42 | .4117 | 283 | 2,862 | 5,722 | 4,292 | 1.58 | 1.04 | 1.31 | 1,743 | 36.9 | 80 | 71 | 68 | 81 | ........ |
| (1) | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | 145 | 34 | .00363 | 19.20 | 5.292 | .5650 | 150 | 2,890 | 6,012 | 4,451 | 2.42 | 1.06 | 1.74 | 2,293 | 52.5 | 61 | 41 | 32 | 166 | ........ |
| 98 | 146 | 34 | .00349 | 17.30 | 4.957 | .5088 | 134 | 2,832 | 5,694 | 4,263 | 2.56 | 1.34 | 1.95 | 2,238 | 62.6 | 54 | 35 | 29 | 182 | ........ |
| 99 | 193 | 30 | .00318 | 13.15 | 4.135 | .4385 | 175 | 2,881 | 6,287 | 4,584 | 1.88 | 1.02 | 1.45 | 2,421 | 59.7 | 65 | 43 | 35 | 157 | ........ |
| 100 | 165 | 33 | .00347 | 16.25 | 4.684 | .4926 | 161 | 2,715 | 5,345 | 4,030 | 2.50 | 1.32 | 1.91 | 2,117 | 51.0 | 54 | 37 | 30 | 179 | ........ |
| 101 | 196 | 31 | .00337 | 15.20 | 4.51 | .4905 | 185 | 2,630 | 5,538 | 4,084 | 1.98 | 1.14 | 1.56 | 2,072 | 45.0 | 55 | 38 | 31 | 176 | ........ |
| 102 | 186 | 33 | .00338 | 16.15 | 4.780 | .4895 | 186 | 3,114 | 5,732 | 4,423 | 1.80 | .96 | 1.38 | 2,350 | 48.5 | 43 | 30 | 22 | 205 | ........ |
| 103 | 158 | 33 | .00417 | 12.40 | 2.974 | .3757 | 211 | 2,863 | 5,107 | 3,985 | 1.94 | 1.20 | 1.57 | 1,801 | 50.3 | 78 | 64 | 57 | 101 | ........ |
| 104 | 159 | 34 | .00350 | 16.50 | 4.715 | .4851 | 158 | 3,392 | 5,760 | 4,576 | 2.20 | 1.28 | 1.74 | 2,137 | 59.7 | 76 | 64 | 57 | 103 | ........ |
| 105 | 187 | 32 | .00386 | 16.50 | 4.280 | .5160 | 158 | 3,575 | 5,945 | 4,760 | 1.76 | .92 | 1.34 | 2,339 | 58.3 | 74 | 59 | 50 | 117 | ........ |
| 106 | 195 | 30 | .00353 | 14.85 | 4.21 | .495 | 180 | 2,901 | 5,891 | 4,396 | 2.16 | 1.00 | 1.59 | 2,060 | 49.4 | 72 | 58 | 49 | 121 | ........ |
| 107 | 194 | 33.2 | .00375 | 17.55 | 4.68 | .529 | 171 | 3,395 | 6,328 | 4,860 | 2.20 | .98 | 1.59 | 2,455 | 53.6 | 68 | 53 | 44 | 135 | ........ |
| 108 | 135 | 31 | .00386 | 13.95 | 3.616 | .4536 | 196 | 3,048 | 5,460 | 4,254 | 2.32 | 1.18 | 1.75 | 1,942 | 47.8 | 78 | 62 | 53 | 107 | ........ |
| 109 | 136 | 33 | .00375 | 17.35 | 4.630 | .5258 | 157.5 | 3,155 | 5,900 | 4,528 | 2.48 | 1.24 | 1.86 | 2,203 | 54.6 | 65 | 48 | 41 | 146 | ........ |
| 110 | 139 | 34 | .003735 | 21.30 | 5.703 | .6266 | 155 | 3,200 | 6,176 | 4,688 | 2.30 | 1.32 | 1.81 | 2,473 | 48.1 | 59 | 42 | 36 | 163 | ........ |
| 111 | 138 | 34 | .003645 | 20.45 | 5.612 | .6015 | 150.8 | 3,343 | 6,620 | 4,970 | 2.38 | 1.26 | 1.82 | 2,590 | 54.9 | 54 | 38 | 30 | 178 | ........ |
| | 144 | 32 | .0032 | 18.50 | 5.78 | .5781 | 157 | 3,270 | 6,100 | 4,685 | 2.18 | 1.22 | 1.70 | 2,490 | 51.6 | 57 | 40 | 30 | 173 | ........ |
| 112 | 142 | 20 | .00393 | 11.50 | 2.928 | .3834 | 197 | 2,731 | 4,711 | 3,721 | 1.62 | .98 | 1.30 | 1,580 | 49.3 | 88 | 74 | 67 | 71 | ........ |
| 113 | 148 | 32 | .00328 | 18.15 | 5.536 | .5674 | 170 | 2,860 | 4,870 | 3,865 | 2.42 | 1.36 | 1.89 | 2,130 | 40.0 | 54 | 34 | 27 | 185 | ........ |
| 114 | 149 | 31 | .00398 | 10.25 | 2.578 | .3307 | 223 | 2,362 | 4,066 | 3,214 | 1.74 | 1.08 | 1.41 | 1,430 | 43.5 | 85 | 76 | 65 | 74 | ........ |
| 115 | 151 | 33 | .00398 | 14.00 | 3.518 | .4241 | 213 | 3,074 | 5,510 | 4,292 | 2.12 | 1.04 | 1.58 | 1,950 | 47.5 | 71 | 53 | 47 | 129 | ........ |
| 116 | 150 | 31 | .00341 | 17.15 | 5.030 | .5500 | 185 | 2,774 | 5,874 | 4,324 | 2.54 | 1.12 | 1.83 | 2,236 | 42.5 | 63 | 48 | 41 | 148 | ........ |
| 117 | 185 | 31 | .00337 | 16.95 | 5.030 | .5470 | 195 | 2,902 | 5,995 | 4,448 | 1.86 | 1.00 | 1.43 | 2,379 | 41.7 | 51 | 33 | 25 | 191 | ........ |
| 118 | 155 | 32 | .00337 | 14.30 | 4.245 | .4470 | 228 | 2,826 | 5,010 | 3,918 | 2.84 | 1.04 | 1.94 | 2,158 | 38.4 | 51 | 32 | 27 | 190 | ........ |
| 119 | 156 | 32 | .00323 | 14.15 | 4.380 | .4430 | 223 | 2,768 | 4,748 | 3,758 | 3.12 | 1.02 | 2.07 | 2,122 | 38.0 | 42 | 26 | 20 | 212 | ........ |
| 120 | 153 | 31 | .00422 | 8.35 | 1.979 | .2694 | 216 | 2,572 | 3,910 | 3,241 | 1.74 | .92 | 1.33 | 1,315 | 55.6 | 80 | 70 | 61 | 89 | ........ |
| 121 | 152 | 33 | .00429 | 12.20 | 2.843 | .3698 | 178 | 2,870 | 4,722 | 3,796 | 1.44 | 1.00 | 1.22 | 1,731 | 57.7 | 85 | 74 | 67 | 74 | ........ |
| 122 | 173 | 34 | .00408 | 14.25 | 3.50 | .419 | 212 | 2,580 | 4,565 | 3,568 | 2.44 | 1.20 | 1.82 | 1,590 | 40.1 | 65 | 56 | 52 | 127 | ........ |
| 123 | 157 | 34 | .00416 | 12.65 | 3.040 | .3720 | 234 | 3,064 | 4,442 | 3,753 | 1.88 | 1.06 | 1.47 | 1,748 | 43.1 | 89 | 78 | 74 | 59 | ........ |
| 124 | 134 | 32 | .00386 | 12.45 | 3.225 | .3890 | 204 | 2,716 | 4,765 | 4,740.5 | 1.74 | 1.20 | 1.47 | 1,701 | 47.0 | 88 | 82 | 72 | 58 | ........ |
| 125 | 141 | 31 | .00365 | 14.35 | 3.932 | .4630 | 207 | 3,288 | 5,460 | 4,374 | 2.22 | 1.36 | 1.79 | 2,080 | 45.8 | 93 | 82 | 76 | 49 | ........ |
| 126 | 131 | 32 | .003515 | 15.35 | 4.369 | .4796 | 284 | 3,172 | 5,185 | 4,178.5 | 2.96 | 1.38 | 2.17 | 2,078 | 30.7 | 91 | 81 | 73 | 55 | ........ |
| 127 | 133 | 33 | .0043 | 13.775 | 3.204 | .4175 | 196 | 2,574 | 4,212 | 3,393 | 2.68 | 1.38 | 2.03 | 1,672 | 41. | 89 | 75 | 69 | 67 | ........ |
| 128 | 188 | 32.4 | .00373 | 15.10 | 4.05 | .4660 | 199 | 3,257 | 5,585 | 4,421 | 1.84 | .96 | 1.40 | 2,101 | 47.5 | 88 | 72 | 68 | 72 | ........ |
| 129 | 154 | 31 | .00334 | 16.40 | 4.910 | .5290 | 288 | 3,810 | 6,348 | 5,079 | 2.58 | 1.22 | 1.90 | 2,448 | 33.3 | 79 | 69 | 57 | 95 | ........ |
| 130 | 137 | 34 | .00352 | 19.40 | 5.514 | .5709 | 169.5 | 3,152 | 6,072 | 4,612 | 2.38 | 1.14 | 1.76 | 2,334 | 47.6 | 61 | 39 | 31 | 169 | ........ |
| 131 | 124 | 30 | .0031 | 19.90 | 6.41 | .663 | 150 | 2,684 | 5,350 | 4,017 | 1.90 | 1.36 | 1.63 | 2,195 | 40.5 | 77 | 57 | 49 | 117 | ........ |
| 132 | 125 | 33 | .00332 | 22.3 | 6.72 | .675 | 173 | 2,876 | 5,552 | 4,214 | 2.36 | 1.42 | 1.89 | 2,224 | 36.2 | 63 | 46 | 39 | 152 | ........ |
| 133 | 126 | 34 | .00405 | 15.1 | 3.73 | .444 | 196 | 2,958 | 4,662 | 3,810 | 2.26 | 1.38 | 1.82 | 1,815 | 43.8 | 94 | 83 | 74 | 49 | ........ |
| 134 | 189 | 31 | .00379 | 11.90 | 3.14 | .3839 | 255 | 3,152 | 5,712 | 4,432 | 1.68 | 1.06 | 1.37 | 2,068 | 45.3 | 83 | 72 | 66 | 79 | ........ |
| 135 | 140 | 30 | .003755 | 10.55 | 2.810 | .3518 | 199 | 2,700 | 4,591 | 3,645.5 | 1.58 | 1.00 | 1.29 | 1,596 | 52.3 | 89 | 79 | 69 | 63 | ........ |
| 136 | 129 | 34 | .004555 | 13.35 | 2.93 | .3928 | 183 | 2,466 | 3,958 | 3,212 | 2.92 | 1.18 | 2.05 | 1,437 | 44.5 | 87 | 74 | 68 | 71 | ........ |

[1] 92–96, inclusive, qualitative grinder runs (no production data). No pulp made for paper machine runs.

TABLE 5.—*Quality tests of papers manufactured from experimental pulps*—Continued.

| Grinder run number. | Paper-machine run number. | Weight per ream. | Thickness. | Mullen test. | | | | Schopper tests. | | | | | | | | Tintometer indications. | | | | Microscopic classification. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total. | Per 0.001 inch of thickness. | Per pound. | Horsepower per ton divided by strength factor. | Breaking length. Crosswise. | Breaking length. Lengthwise. | Breaking length. Average. | Stretch. Crosswise. | Stretch. Lengthwise. | Stretch. Average. | Breaking weight per square millimeter, sectional area. | Breaking length per horsepower per ton. | Red. | Green. | Blue. | Black. | |
| | | *Pounds.* | *Inches.* | *Points.* | *Points.* | *Points.* | | *Meters.* | *Meters.* | *Meters.* | *Per ct.* | *Per ct.* | *Per ct.* | *Grams.* | *Meters.* | *Parts.* | *Parts.* | *Parts.* | *Parts.* | |
| 137 | 127 | 32 | 0.00378 | 16.85 | 4.46 | 0.5267 | 244 | 3,600 | 6,004 | 4,802 | 1.96 | 1.12 | 1.54 | 2,526 | 37.4 | 84 | 74 | 65 | 77 | ........ |
| 138 | 121 | 31 | .00359 | 15.25 | 4.25 | .492 | 200 | 3,255 | 4,920 | 4,088 | 2.98 | 1.34 | 2.16 | 1,952 | 41.5 | 86 | 73 | 67 | 74 | ........ |
| 139 | 123 | 33 | .00409 | 16.95 | 4.15 | .514 | 155 | 2,962 | 4,776 | 3,869 | 2.74 | 1.36 | 2.05 | 1,830 | 48.6 | 87 | 76 | 69 | 68 | ........ |
| 140 | 143 | 31 | .00356 | 15.00 | 4.212 | .4840 | 263 | 3,810 | 5,840 | 4,825 | 2.40 | 1.12 | 1.76 | 2,253 | 38.0 | 87 | 76 | 66 | 71 | ........ |
| 141 | 130 | 32 | .004045 | 15.25 | 3.77 | .4766 | 194 | 2,740 | 4,590 | 3,665 | 2.98 | 1.40 | 2.19 | 1,756 | 39.6 | 80 | 72 | 67 | 81 | ........ |
| 142 | 132 | 32 | .0042 | 11.80 | 2.809 | .3689 | 218 | 2,452 | 3,968 | 3,210 | 2.44 | 1.30 | 1.87 | 1,495 | 39.9 | 89 | 78 | 72 | 61 | ........ |
| 143 | 122 | 33 | .00426 | 14.8 | 3.47 | .448 | 186 | 2,805 | 4,380 | 3,593 | 2.34 | 1.32 | 1.83 | 1,608 | 43.1 | 86 | 76 | 68 | 70 | ........ |
| 144 | 118 | 31 | .00414 | 14.05 | 3.54 | .4725 | 178 | 2,712 | 4,350 | 3,531 | 2.44 | 1.40 | 1.92 | 1,660 | 41.9 | 87 | 76 | 72 | 65 | ........ |
| 145 | 128 | 33 | .004185 | 13.175 | 3.149 | .3993 | 198 | 2,831 | 4,981 | 3,906 | 1.90 | 1.10 | 1.50 | 1,605 | 49.4 | 88 | 79 | 70 | 63 | ........ |
| 146 | 168 | 31 | .00375 | 12.10 | 3.228 | .3902 | 246 | 3,086 | 4,716 | 3,901 | 1.60 | 1.04 | 1.32 | 1,805 | 40.5 | 83 | 70 | 64 | 83 | ........ |
| 147 | 160 | 35 | .00407 | 14.65 | 3.599 | .4187 | 210 | 3,266 | 4,680 | 3,973 | 2.84 | 1.22 | 2.03 | 1,917 | 45.0 | 85 | 76 | 68 | 71 | ........ |
| 148 | 164 | 32 | .00405 | 12.50 | 3.087 | .3906 | 220 | 2,728 | 4,860 | 3,794 | 2.14 | 1.26 | 1.70 | 1,846 | 44.2 | 83 | 72 | 65 | 80 | ........ |
| 149 | 174 | 33 | .00350 | 11.00 | 3.140 | .3375 | 302 | 2,658 | 4,628 | 3,643 | 2.58 | 1.36 | 1.97 | 1,730 | 35.8 | 66 | 56 | 50 | 128 | ........ |
| 150 | 161 | 32 | .00398 | 12.35 | 3.104 | .3859 | 254 | 3,064 | 4,554 | 3,809 | 2.20 | 1.10 | 1.65 | 1,848 | 38.9 | 80 | 69 | 64 | 87 | ........ |
| 151 | 162 | 34 | .00418 | 14.70 | 3.518 | .4326 | 217 | 3,162 | 4,818 | 3,990 | 2.40 | 1.16 | 1.78 | 1,944 | 42.5 | 84 | 72 | 68 | 76 | ........ |
| 152 | 197 | 30.4 | .00355 | 15.10 | 4.25 | .4965 | 345 | 3,401 | 6,259 | 4,830 | 1.66 | 1.04 | 1.35 | 2,305 | 28.2 | 89 | 77 | 73 | 61 | ........ |